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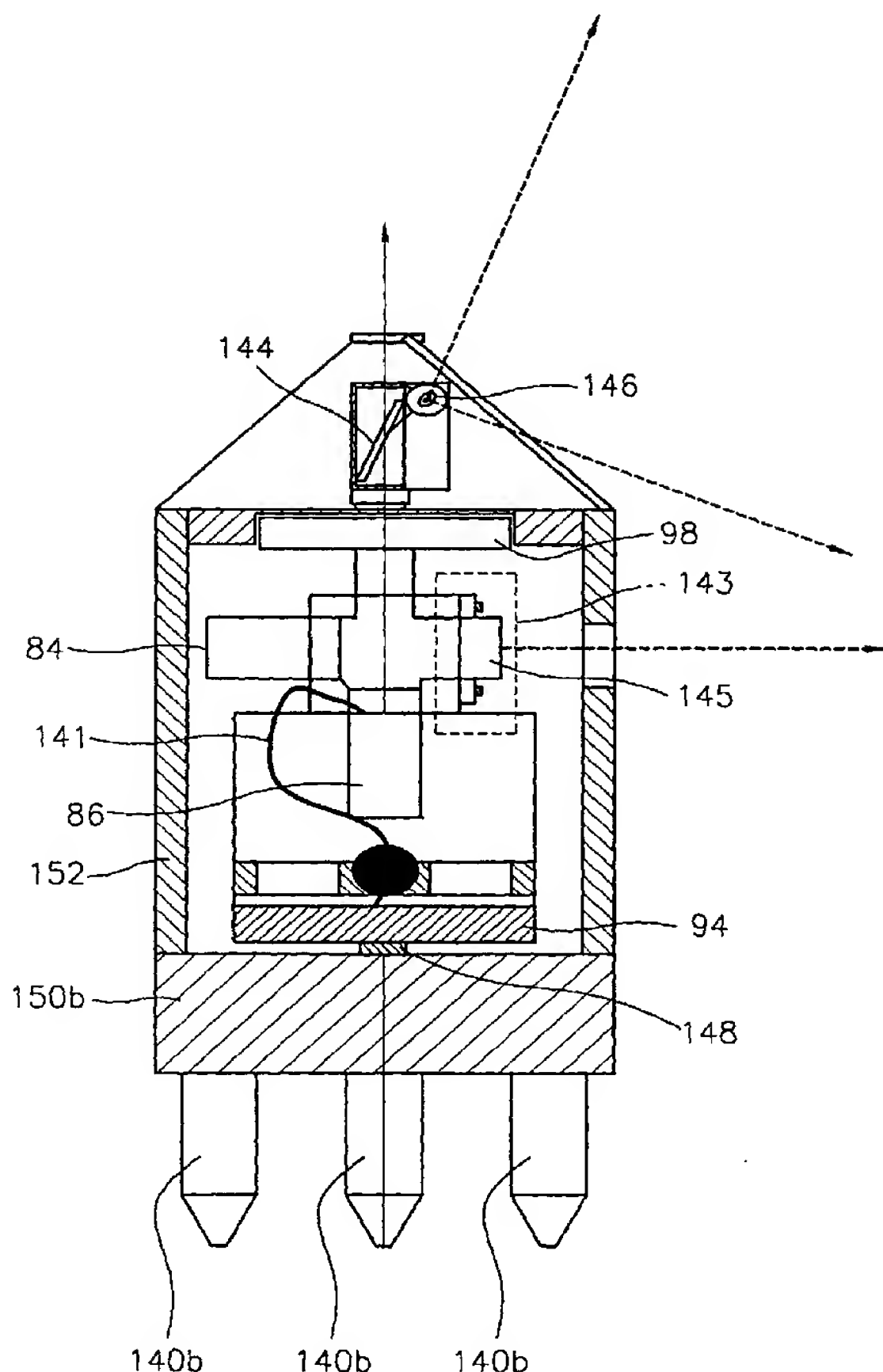
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(75) Inventor/Applicant (*for US only*): **TAK, Seung-Ho**  
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(54) Title: LEVEL AND/OR VERTICALITY INDICATOR USING LASER BEAMS



(57) Abstract: A levelness and or vertically indicator using a laser beam is provided in which a laser beam emitted from a laser beam scanning mechanism (4) is converted to a laser beam line by using a cylindrical lens (145) or a polygonal rotary mirror and the laser beam line is used for indicating levelness and or vertically and a vertical point with the bear eyes by a calibration process for matching the laser beam line with a reference levelness line. The levelness and or vertically indicator includes a laser diode (50a) for emitting a laser beam, a laser beam converting and outputting unit for converting the received laser beam and outputting the converted laser beam, and a portion for providing a reference levelness so that the laser beam line output from the laser beam converting and outputting unit maintains the reference levelness. Also, the pendulum movement of a weight plumb (94) is stopped quickly due to magnetic resistance so that the real levelness and vertically and a vertical point are convenient are indicated by using a laser beam. Thus, the time and work amount needing for indicating levelness and or verticality is reduced. Further, when a an object to be worked on is huge, levelness and or verticality can be effectively indicated.



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## LEVEL AND/OR VERTICALITY INDICATOR USING LASER BEAMS

### Technical Field

5           The present invention relates to a levelness and/or verticality indicator using laser beams, and more particularly, to a levelness and/or verticality indicator using laser beams which can effectively indicate levelness and/or verticality and a plumb point by converting laser beams emitted from a laser beam scanning mechanism to a laser beam line and  
10   outputting the same while maintaining a reference levelness.

### Background Art

          Generally, when a construction structure is built at a construction site, horizontality is indicated by adjusting a levelness so that a bubble  
15   formed in a glass tube filled with liquid forming a seal can be positioned at the center thereof. Then, a string or steel wire is positioned corresponding to the horizontal surface of the levelness so that bricks can be laid or timbers can be horizontally set corresponding to the horizontal surface or line. Also, to set a vertical line, a plumb tied to a string is used and a  
20   column is erected corresponding to the vertical line. Thus, the construction structure is balanced. FIG. 1 shows a conventional levelness indicating device (a levelness) for indicating levelness by checking the position of a bubble in a glass tube with the naked eye. FIG. 2 shows a conventional verticality indicator for indicating verticality by forming a plumb line using  
25   a string and a plumb tied to the string, which hangs due to gravity.

          In addition to the need at the construction site, when two or more picture frames or mirrors are to be fixed on a wall inside a building, it is difficult to set levelness and verticality. Also, at a site where mass structures such as existing buildings, engineering works and ships are  
30   welded, or huge statues or artistic works are built, levelness and vertical

tasks need a string and plumb, a levelness, and an indicator so that a great amount of time and amount of work is needed for installing the string and plumb and the levelness and changing the positions thereof. Also, although a levelness indicator can be used microscopically at every position, horizontal and vertical tasks become very difficult since the object cannot be observed macroscopically. Although there are laser indicators, they usually indicate a laser point not a laser beam line. In the case of the conventional laser indicator capable of indicating a laser beam line, production and a controlling method thereof are very difficult so that the price of the indicator is high and the method of using it is very complicated and difficult to learn by a user, thus lowering productivity at the site of work.

#### Disclosure of the Invention

To solve the above problems, it is an objective of the present invention to provide a levelness and/or verticality indicator using laser beams, which makes work easy and is easy to handle.

It is another objective of the present invention to provide a levelness and/or verticality indicator using laser beams, which may be applied to a large workpiece.

It is yet another objective of the present invention to provide a levelness and/or verticality indicator using laser beams, which can indicate levelness and/or verticality while automatically maintaining levelness.

It is still another objective of the present invention to provide a levelness and/or verticality indicator using laser beams, which can be safely used by adopting an eyesight protecting means for protecting eyesight from a laser beam.

It is yet still another objective of the present invention to provide a levelness and/or verticality indicator using laser beams, which can be effectively used by adopting a remote controlling means.

It is yet still another objective of the present invention to provide a levelness and/or verticality indicator and a plumb point indicator using laser beams, which makes work easy and is easy to handle.

It is yet still further another objective of the present invention to  
5 provide a levelness and verticality indicator using laser beams, which can quickly indicate levelness and/or verticality by making a plumb quickly maintain levelness and verticality.

To accomplish the above objectives of the present invention, there is provided a levelness and verticality indicator for indicating levelness and  
10 verticality by using a laser beam, which comprises a laser beam scanning mechanism for emitted a laser beam, means for converting the laser beam emitted by the laser beam scanning mechanism to a laser beam line and outputting the laser beam line, and a reference levelness maintaining means for supporting the laser beam line to be output while keeping the  
15 levelness.

It is preferred in the present invention that the laser beam scanning mechanism comprises a modulation circuit for modulating a pulse interval and pulse width in response to a received predetermined electric power, and a laser diode for emitting a laser beam in response to a modulation  
20 signal received from the modulation circuit.

It is preferred in the present invention that the laser beam line converting and outputting means is a cylindrical lens which is partially cut-processed in a lengthwise direction so that a focused laser beam is converted to a laser beam line.

It is preferred in the present invention that the laser beam converting  
25 and outputting means further comprises means for rotating the cylindrical lens by  $90^\circ$  so that the laser beam line is output in a state of being rotated by  $90^\circ$ .

It is preferred in the present invention that the laser beam line  
30 converting and outputting means comprises a polygonal rotary mirror

rotating at a predetermined speed for reflecting the laser beam so that the focused laser beam is converted to a laser beam line, and a motor for rotating the polygonal rotary mirror at a predetermined speed.

5           It is preferred in the present invention that the reference levelness maintaining means comprises an upper spherical body which is partially cut-processed to accommodate the laser beam scanning mechanism, a support body having a micro bearing means formed on the upper surface thereof so that the upper spherical body is accommodated on three points,  
10           and a lower spherical body having a diameter greater than that of the upper spherical body and coupled to the upper spherical body by the support body, so that balance in a vertical direction is automatically maintained and accordingly the levelness of the laser beam scanning mechanism of the upper spherical body is maintained.

15           It is preferred in the present invention that the reference levelness maintaining means is a liquid levelness indicator in which a built-in laser beam scanning mechanism for scanning a laser beam through a laser beam scanning window formed at one side of the reference levelness maintaining means is installed at a particular space in the liquid levelness indicator, and  
20           the levelness of the laser beam scanning mechanism installed in the liquid levelness indicator is manually adjusted according to the position of a bubble in the liquid levelness indicator.

          It is preferred in the present invention that the levelness indicator includes an upper unit and a lower unit, and when the indicator is used as  
25           a levelness indicator, the upper unit and the lower unit are folded with respect to each other and a cantilever connected to the upper unit slides along a groove formed on the upper surface of the lower unit and is folded, and when the indicator is used as a verticality indicator, the upper unit and the lower unit are unfolded with respect to each other and the cantilever  
30           slides along the groove and is unfolded.



It is preferred in the present invention that the indicator further comprises a tripod connected to a hole formed at the lower surface of the indicator for adjusting the height of the indicator to form a horizontal line and a vertical line of a laser beam.

5 It is preferred in the present invention that the indicator further comprises a window formed at one side of the indicator for receiving a remote control signal from a remote controller, and a processor installed in the indicator for processing the remote control signal to provide the processed remote control signal to the laser beam scanning mechanism.

10 It is preferred in the present invention that the indicator further comprises an eye protecting circuit for cutting off the electric power of the laser beam scanning mechanism in response to a power cut-off control signal received from a transmitting portion for transmitting a control signal for cutting off the electric power of the laser beam scanning mechanism  
15 when it detects the laser beam line.

It is preferred in the present invention that the transmitting portion is installed in a pair of glasses or a helmet worn by a worker to protect the eyesight of the worker.

It is preferred in the present invention that the reference levelness  
20 maintaining means comprises a cylindrical floating body having a deck provided at an upper portion thereof for accommodating the laser beam scanning mechanism, a calibrator including weight plumbs at three points on the deck placed on the upper portion of the floating body, a rod connecting the weight plumbs, and an adjustment plumb for adjusting the  
25 levelness of the laser beam scanning mechanism by moving along the rod shape, a pipe vertically formed in the floating body and in which batteries are inserted, a spherical plumb connected at the lower end of the through hole, and an outer box containing liquid on which the floating body floats while the spherical plumb is connected.

30 To accomplish the above objectives of the present invention, there

is provided a levelness and verticality indicator using a laser beam comprising a gyrohorizon fixed at the upper portion of an outer box body and having a central portion capable of rotating and moving in all directions, a weight plumb means hanging from the central portion of the  
5 gyrohorizon and performing pendulum movement, a levelness and verticality laser engine engaged with the weight plumb means and emitting a laser beam in horizontal and vertical directions, a levelness and verticality laser beam converting and outputting means engaged with the weight plumb means and diffusing and outputting the laser beam emitted from the  
10 levelness and verticality laser engine to the same plane as a horizontal or vertical surface, and a swing dampening portion for quickly dampening the pendulum movement of the weight plumb means to a stable vertical position.

It is preferred in the present invention that the levelness and vertical  
15 laser engine comprises a modulation circuit for modulating pulse interval and pulse width in response to a predetermined electrical power, a laser diode for emitting a laser beam by being driven by a modulation signal from the modulation circuit, and a collimating lens for focusing the diffused laser beam.

20 It is preferred in the present invention that the levelness and vertical laser beam line converting and outputting means comprises a cylindrical lens which diffuse the vertically input laser beam to the same horizontal or vertical surface as the circular sections of the cylindrical lens and outputs the diffused laser beam as a laser beam line.

25 It is preferred in the present invention that the levelness and vertical laser beam line converting and outputting means further comprises a height adjusting means for adjusting the height of the cylindrical lens in the forward and backward directions, and a left and right rotating means for adjusting a degree of inclination to the left or right side.

30 It is preferred in the present invention that the weight plumb means



is a copper plate.

It is preferred in the present invention that the weight plumb means further comprises a weight plumb adjusting portion for adjusting movement of the center of gravity of the weight plumb.

5 It is preferred in the present invention that the weight plumb adjusting means adjusts the center of weight by adjusting the position of a bolt.

It is preferred in the present invention that the swing dampening portion is a multiple pole magnet ring which is fixedly arranged at the lower  
10 portion of the outer box and separated from the weight plumb means to be vertically thereunder.

It is preferred in the present invention that the vertical laser beam line converting and outputting means further comprises an optical fiber for receiving a laser beam emitted from the vertical laser engine and passing  
15 through a collimating lens and outputting the laser beam in a vertically downward direction, and a focusing lens for collecting the laser beam transmitted through the optical fiber and displaying a vertical point on the bottom surface where a body of the outer box is located.

It is preferred in the present invention that the gyrohorizon  
20 comprises an outer ring fixed to the upper portion of the outer box, an intermediary ring arranged inside the outer ring and rotatably installed by being coupled to the outer ring via a bearing shaft in a radial direction, and a center ring arranged inside the intermediary ring and coupled to the intermediary ring via the bearing shaft to be capable of rotating in a  
25 direction perpendicular to a direction that the intermediary ring rotates, wherein the inside of the center ring is coupled to the weight plumb means to be engaged with each other.

It is preferred in the present invention that the vertical laser beam line converting and outputting means comprises a beam splitter for  
30 transmitting some of a laser beam emitted from the vertical laser engine in

an upward direction to display a vertically upper point, and reflecting the remaining laser beam toward the vertical cylindrical lens to display a vertical line.

5 Brief Description of the Drawings

FIG. 1 is a perspective view showing a conventional liquid sealed levelness.

FIG. 2 is a view showing a conventional method of setting verticality by using a string and a plumb;

10 FIG. 3 is a view showing a laser beam scanning mechanism according to a preferred embodiment of the present invention;

FIG. 4 is an exploded perspective view showing the optical configuration of the laser beam scanning mechanism of FIG. 3;

15 FIG. 5 is an assembled perspective view showing the optical configuration of the laser beam scanning mechanism of FIG. 3;

FIG. 6 is a side sectional view showing the structure for rotating the laser beam scanning mechanism of FIG. 3 by 90°;

20 FIG. 7 is a view schematically showing a laser beam scanning mechanism according to another preferred embodiment of the present invention;

FIGS. 8 and 9 are views showing laser beams reflected by surfaces of a polygonal rotating mirror according to a rotary angle of the polygonal rotating mirror;

25 FIG. 10A is a front view showing a preferred embodiment of an apparatus for maintaining reference levelnesss of the laser beam scanning mechanisms shown in FIGS. 3 and 7;

FIGS. 10B and 10C are a front view and a plan view, respectively, showing another preferred embodiment of the apparatus for maintaining the reference levelness of the laser beam scanning mechanisms shown in  
30 FIGS. 3 and 7;

FIG. 11 is a sectional view taken along line I-I of FIG. 10A;

FIGS. 12A through 12D are views showing examples of maintaining levelness with respect to an inclined surface in the case in which the laser beam scanning mechanism of the present invention adopts the levelness  
5 maintaining apparatus of FIG. 10A;

FIG. 13 is a perspective view showing the levelness maintaining apparatus of the laser beam scanning mechanisms shown in FIGS. 3 and 7 according to yet another preferred embodiment of the present invention;

FIG. 14 is a perspective view showing the shape of the levelness  
10 indicator converted to a verticality indicator and the 360° rotating structure of the indicator;

FIGS. 15 and 16 are views showing a levelness and/or verticality indicator using laser beams according to the present invention, to which a tripod is attached;

15 FIGS. 17 and 18 are perspective views showing the levelness and/or verticality indicator using laser beams with a tripod of FIG. 15, which is used for bricklaying in a levelness direction and a vertical direction;

FIGS. 19 and 20 are perspective views showing the levelness and/or verticality indicator using laser beams with a tripod of FIG. 16, which is  
20 used for bricklaying in a levelness direction and a vertical direction;

FIGS. 21A and 21B are views for explaining a step of calibrating an accurate levelness in a process of manufacturing the levelness and/or verticality indicator using laser beams according to the present invention;

FIGS. 22A and 22B are views for explaining the function of a  
25 reflection sheet used for a vertical task of a large construction;

FIG. 23 is a view showing glasses for protecting eyesight from a laser beam and a laser beam automatic cutting circuit;

FIG. 24 is a view for explaining a remote control transmitter and receiving means for controlling a period of emission of a laser beam by  
30 remotely controlling the levelness and/or verticality indicator using laser

beams of the present invention;

FIG. 25 is a view for explaining a case in which the indicator of the present invention is placed on a multi-joint balancing apparatus while work is done;

5        FIG. 26 is a view showing a case in which the indicator of the present invention is adopted to a gyrocompass applied to an airplane and a ship;

FIG. 27 is a view showing the structure for absorbing vibrations and impacts which is installed at the outer surface of the indicator of the present  
10    invention;

FIG. 28 is a view showing a beam emitting mechanism of a laser diode for explaining another preferred embodiment of the present invention;

FIG. 29 is a view for explaining the structure indicating an indication point at predetermined position by using part of a divergent beam in FIG.  
15    28;

FIG. 30 is an exploded perspective view showing a laser engine optical portion for matching the center angle of the divergent beam to the lengthwise direction of a cylindrical case of a laser engine;

FIG. 31 is a sectional view showing the laser engine optical portion  
20    of FIG. 30;

FIG. 32 is a sectional view showing an optical structure in the state in which the laser diode of FIG. 30 is matched to a body tube of the engine without considering the center angle;

FIG. 33 is a sectional view showing an optical structure in the state  
25    in which the beam of the laser diode of FIG. 30 is matched to the center line of the collimating lens;

FIG. 34 is a view for explaining the indicator using the laser engine according to another preferred embodiment of the present invention;

FIG. 35 is an exploded perspective view for explaining the structure  
30    of the gyrohorizon of FIG. 34;

FIG. 36 is a sectional view showing in detail the intermediary ring and the outer ring of FIG. 35;

FIG. 37 is a plan view of a multi-pole magnet ring of FIG. 34;

FIG. 38 is a view for explaining the relationship in magnetic brake  
5 between the multi-pole magnet ring and the plumb;

FIG. 39 is a sectional view of the indicator shown in FIG. 34;

FIG. 40 is a sectional view showing divergence on the same plane of a laser beam incident upon the cylindrical lens;

FIGS. 41 and 42 are views showing the state in which the beam is  
10 divergent according to the angle of the beam incident perpendicular to the cylindrical lens;

FIGS. 43 and 44 are views for explaining the relationship of a levelness beam line of a beam according to the angle of the beam incident to be inclined to the cylindrical lens; and

15 FIGS. 45 and 46 are a cross sectional view and a top view for explaining the structure of housing of the cylindrical lens for adjusting the posture of the cylindrical lens with respect to another preferred embodiment of the present invention.

## 20 Best mode for carrying out the Invention

The structure and operation of a levelness and/or verticality indicator using laser beams according to preferred embodiment of the present invention will be described in detail with reference to the attached drawings.

The present invention is related to a levelness and/or verticality  
25 indicator using laser beams which can be conveniently used at construction sites or in an installation procedure of interior decorations. The present invention is a device for conveniently obtaining horizontal and/or vertical positions.

The levelness and/or verticality indicator using laser beams  
30 according to the present invention, as shown in FIG. 3, includes a laser

beam generating mechanism 4 for generating a laser beam, and a laser beam line conversion output means 6 for converting the laser beam generated by the laser beam generating mechanism 4 to a laser beam line and outputting the converted laser beam line. The laser beam generating  
5 mechanism 4 includes a modulation circuit 2 for receiving a predetermined electric power 3 and modulating a pulse interval and a pulse width, a laser diode 41 driven according to a modulation signal from the modulation circuit, for emitting a laser beam, and a collimating focus lens 42 for concentrating a laser beam from the laser diode. The laser beam line  
10 conversion output means 6 is formed of a cylindrical lens 6 partially machined in its lengthwise direction, and a laser beam line 8 is formed by the cylindrical lens 6.

As shown in the drawing, since the interval and size of a p-type and n-type combined semiconductor diode are small and a reflection surface is  
15 narrow, the laser beam generated by the laser diode 41 is output by being dispersed at a predetermined angle. The laser beam is concentrated at a particular size through the collimating focus lens 42 and passes through the cylindrical lens so that the laser beam is spread to a predetermined width, obtaining a linear line. Although not described in detail in the drawing,  
20 since a pulse generating circuit and a laser diode driving circuit related to the laser beam generating mechanism applied to the present invention, that is, driving of the laser diode, can be easily understood by one skilled in the art, a detailed description thereof will be omitted.

The laser beam scanning mechanism adopting a cylindrical lens as  
25 a laser beam line conversion output means is described with reference to FIGS. 4 through 6. FIG. 4 is an exploded perspective view showing the optical structure of the laser beam scanning mechanism of FIG. 3. FIG. 5 is an assembled perspective view showing the optical structure of the laser beam scanning mechanism of FIG. 3. FIG. 6 is a sectional view showing  
30 the structure for rotating the laser beam scanning mechanism of FIG. 3 by



90°.

As shown in FIGS. 4 through 6, a laser beam scanning mechanism applied to the present invention has a structure similar to a lens assembly of a camera. A cylindrical fixing portion 410 is fixedly attached to a body of the indicator of the present invention and an assembly of the laser beam scanning mechanism is inserted in the fixing portion. The laser beam scanning mechanism includes a levelness calibrator 411 for performing levelness calibration, in which the laser diode 41 is detachably inserted, a coupling portion 422 coupled to the levelness calibrator 411 to enclose the laser diode 41, a focusing portion 42 fixed to the coupling portion 422 and including a collimating focus lens capable of adjusting the focus and width of a laser beam, a converting portion 5 for converting the laser beam output from the focusing portion 42 to a laser beam line, in which the cylindrical lens 6 is inserted, and a window portion 7 for outputting the laser beam line.

By pulling the levelness calibrator 411 in the opposite direction with respect to the fixing portion 410 to be slightly separated therefrom and then rotating the levelness calibrator 411 by a predetermined rotation angle, the laser beam line can be converted to a vertical line from a level line, or vice versa. For this purpose, the levelness calibrator 411 can be rotated by a desired angle by matching a line indicated on the surface of the levelness calibrator 411 to a line indicated on the surface of the fixing portion 410. Also, although not shown in the drawings, in another preferred embodiment, the levelness calibrator 411 can convert the laser beam line from a level line to a vertical line or vice versa, by rotating a reduction gear stepping motor or a linear motor with a Hall device by a predetermined rotation angle with respect to the fixing portion 410. In the present preferred embodiment, the lines are marked at a position to be rotated by 90° since the laser beam line is needed to be only converted from the horizontal direction to the vertical direction or from the vertical direction to the horizontal direction.

When the levelness calibrator 411 is to be rotated, the levelness calibrator 411 is rotated while being pulled with respect to the fixing portion 410. When the pulling force is removed after the levelness calibrator 411 is rotated by a predetermined angle, the levelness calibrator 411 is restored  
5 and fixed to the fixing portion 410 by the force of a spring 409. In this case, a structure capable of concurrently rotating the cylindrical lens 6 is sufficient. Since such a structure is usually applied to a typical camera lens assembly which is easy to understand for one skilled in the art, a detailed description thereof will be omitted.

10 In yet another preferred embodiment of the present invention, a polygonal rotating mirror is used instead of the cylindrical lens as the laser beam line conversion output means, which will be described below with reference to the attached drawings.

FIG. 7 shows a laser beam scanning mechanism according to  
15 another preferred embodiment of the present invention. FIGS. 8 and 9 show the positions of reflection of a laser beam with respect to the rotation angles of the polygonal rotating mirror of FIG. 7.

As shown in the drawings, the laser beam scanning mechanism according to another preferred embodiment of the present invention  
20 includes a pulse interval and pulse width modulating circuit 22 for modulating a pulse interval and a pulse width by receiving a predetermined electric power, a laser diode 24 for emitting a laser beam, which is driven by a modulation signal from the modulating circuit 22, a polygonal rotating mirror 26 rotating at a predetermined speed to reflect an incident laser  
25 beam toward a particular display section, and a motor 28 for rotating the polygonal rotating mirror 26 at a predetermined speed.

The position of a laser beam reflected by the rotation of the polygonal rotating mirror 26 is shown in detail in FIGS. 8 and 9. The interval between the points of a laser beam can be reduced by only  
30 increasing the number of rotations of the motor 28. However, since human

eyes recognize a point as a line, not a point, when movement of the point is repeated over 24 times per second, an optical illusion occurs and it is sufficient that the polygonal rotating mirror rotates at least 24 times per second. The principle of obtaining a laser beam line by rotating the  
5 polygonal rotating mirror 26 at a predetermined speed is that as the positions of the incident angle and the reflected angle, that is, an incident point of light with respect to the surface of the polygonal rotating mirror, changes according to the rotation angle of the polygonal rotating mirror, the reflected angle changes so that a reflected point changes by the Snell's  
10 law, in which the incident angle of light and the reflected angle are always the same. Thus, the laser beam appears to be a straight line on a reflective surface such as the surface of a wall of a particular space due to the optical illusion phenomenon in which a human recognizes the continuing points that repeat over 24 times per second to move not to be stationary.

15 When the polygonal rotating mirror 26 is adopted as the laser beam line converting output means, the laser beam scanning mechanism is mechanically formed as in the case of using the cylindrical lens 6 of FIGS. 3 through 6. However, in the present preferred embodiment of the present invention, the motor 28 for rotating the polygonal rotating mirror 26 is  
20 further included. Although not shown in the drawings, a mechanical mechanism for converting the laser beam from a horizontal line to a vertical line or vice versa may be additionally included in the present preferred embodiment. For example, in the preferred embodiment shown in FIG. 7, a structure capable of rotating the overall laser beam scanning mechanism  
25 including the laser beam scanning window 20 through which the laser beam line is output by a predetermined angle will be sufficient. A detailed description thereof will be omitted since the above technology is obvious to one skilled in the art.

As described above, in a laser beam scanning mechanism for  
30 converting a laser beam emitted from a typical laser beam generating

apparatus to a laser beam line and outputting the converted laser beam line, a red visible ray laser having a wavelength of 650 - 670 nanometers is used, which is widely used in a class room to point to items appearing on a black board or a screen. A laser beam spreads at a predetermined angle  
5 from the above-described laser diode and is converted to be a parallel light ray by a collimating focusing lens. The parallel light ray is usually used as a laser pointer which is used in a classroom. Since, the high brightness red visual ray laser can produce a laser beam having a width which does not increase or decrease within a predetermined distance range, a straight line  
10 displayed through a scanning window can be displayed while maintaining a predetermined line width within a visual distance range of several hundred meters.

A levelness and/or verticality indicator using laser beams according to the present invention includes a reference levelness maintaining means  
15 for outputting a laser beam line, that is, a laser straight line, scanned by the laser beam scanning mechanism having the above structure while maintaining a reference levelness. Preferred embodiments of the reference levelness maintaining means are described below in detail with reference to the attached drawings.

20 FIG. 10A is a front view showing a preferred embodiment of a levelness maintaining apparatus of the laser beam scanning mechanism shown in FIGS. 3 through 9. FIG. 11 is a sectional view taken along line I-I of FIG. 10A. FIGS. 12A through 12D are views for explaining examples of maintaining levelness with respect to an inclined surface when the  
25 reference levelness maintaining apparatus of FIG. 10A is adopted in the laser beam scanning mechanism of the present invention.

The reference levelness maintaining means shown in FIG. 10A and FIGS. 11 through 12D includes an upper spherical body 110, a portion of which is milling cut processed to accommodate a laser beam scanning  
30 mechanism 4, a support body 125 having a micro bearing means 120

formed on the upper surface thereof so that the upper spherical body 110 can be supported on three points, and a lower spherical body 130 having a diameter greater than that of the upper spherical body 110 and coupled to the upper spherical body 110 by a pipe 140 through the support body 125 to automatically balance the upper spherical body 110 in a vertical direction so that the laser beam scanning mechanism 4 on the upper spherical body can be horizontally balanced. The support body 125 includes a valve 115 for injecting or exhausting air and an air tube 117 which expands or contracts by the air injected in or exhausted from the valve 115. Thus, the upper spherical body 110 can be fixed during calibration and movement. Also, the pipe 140 connecting the upper spherical body 110 and the lower spherical body 130 penetrates the lower spherical body 130 and is fixed by a cover 160 in the lower portion of the lower spherical body 130. The inside of the pipe 140 is empty so that batteries 150 for supplying electric power to the valve 115 or the laser beam scanning mechanism 4 can be inserted. A fixing means 170 for fixing the lower spherical body 130 during movement is installed under the lower spherical body 130. The fixing means 170 is simply formed of a screw so that, when the body of the fixing means 170 is rotated, the fixing means 170 raises to enclose the lower spherical body 130. Also, the reference levelness maintaining means is covered by an outer box 190 to prevent foreign materials from entering the inside thereof. The outer box 190 is formed of a transparent material so that the inside of the box can be seen from the outside. Also, another fixing means 180 for facilitating installation of the levelness and/or verticality indicator of the present invention on a support pedestal such as a tripod, is installed at the bottom of the outer box 190. The fixing means 180 may have a structure of a screw coupled tripod.

In the operation of the above-described reference levelness maintaining means, since the upper spherical body 110 and the lower spherical body 130 are connected by the pipe 140 so that the upper



spherical body 110 is supported by the lower spherical body 130 functioning as a balance weight due to gravity at three points of the micro bearing means 120 which is formed of three small balls in the support body 125, the upper and lower spherical bodies 110 and 130 tend to remain  
5 vertically oriented. Thus, the laser beam scanning mechanism 4 placed on the upper milling processed surface of the upper spherical body 110 remains horizontally oriented regardless of a degree of levelness of the outer box 190 so that a laser beam line emitted from the laser beam scanning mechanism maintains a reference levelness. Referring to FIGS.  
10 12A through 12D, the operation of the levelness maintaining means is described. Here, for the convenience of explanation, it is assumed that the shape of the outer box 190 of the laser beam scanning mechanism 4 contacting the floor is modified. Although the shape of the outer box 190 of the laser beam scanning mechanism 4 contacting the floor is modified,  
15 since the upper and lower spherical bodies 110 and 130 in the outer box 190 are maintained in a direction of gravity due to the weight of thereof, the upper end surface of the upper spherical body 110 always remains level. Accordingly, the laser beam scanning mechanism 4 placed at the upper end of the upper spherical body 110 is automatically maintained to be level.

20 A reference levelness maintaining means according to another preferred embodiment of the present invention is shown in FIGS. 10B and 10C. An outer box 190a is filled with fluid 188 and a float 125a which has a hollow ship shape and floats on the fluid 188. The laser beam scanning mechanism 4 is provided on a deck 125b at the upper portion of the float  
25 125a. Batteries can be inserted in a pipe 140a penetrating the float 125 and a spherical balance weight 130a is coupled to the lower end of the pipe 140a. The deck 125b is maintained to be level by the operation of gravity on the balance weight 130a in a vertical direction and the buoyancy of the float 125a. Here, during a production process, since it is difficult to balance  
30 the laser beam scanning mechanism and fix it on the deck 125b, the laser



beam scanning mechanism is appropriately fixed and then calibration is performed. The calibration is performed by small balance weights 120a at three points, a rod 115a connecting between the balance weights 120a, and an adjustment balance weight installed to be capable of moving along  
5 the rod 115a so that a laser beam emitted from the laser beam scanning mechanism 4 is adjusted to match. The levelness of two water columns (not shown) located 3 meters in front thereof. This preferred embodiment uses the concept of keeping an object by installing it on a vessel floating on water. In this case, preferably, buoyancy is greater than the weight of the  
10 balance weight and the weight to the three balance weights corresponds to the entire buoyance.

A reference levelness maintaining means of a laser beam scanning mechanism according to yet another preferred embodiment of the present invention uses an existing liquid levelness indicator. As shown in FIG. 13,  
15 the laser beam scanning mechanism is included in the liquid levelness indicator. To levelness the laser beam line, a reference levelness is maintained by visually checking the central position of a bubble in the liquid levelness indicator.

As shown in FIG. 13, a laser beam scanning mechanism (not shown)  
20 for scanning a laser beam through a laser beam scanning window 20 to a particular space in a liquid levelness indicator 10, is included. The laser beam scanning mechanism may be one adopting a cylindrical lens as above or one adopting a polygonal rotary mirror. A detailed description thereof will be omitted here.

25 The laser beam scanning window 20 is an opening formed at the side of the levelness indicator, which is formed of a material for easily transmitting a laser beam such as flat surface processed glass having no refraction. By operating the laser beam scanning mechanism after the central position of a bubble 13 is checked, a laser beam horizontal line  
30 befitting to the reference levelness is emitted through the scanning window

20. Also, another receiving window 30 for receiving a remote control signal enabling remote control is formed in the levelness indicator. Although not shown in the drawings, a process system for processing a received remote signal is installed at the receiving window independent of the laser beam scanning mechanism. Also, the liquid levelness indicator is formed of an upper unit 15 including the laser beam scanning mechanism and a lower unit 15' having a portion to be coupled to a tripod. The upper unit 15 is formed to be raised in a sliding manner so that the upper unit 15 and the lower unit 15' can make a right angle, which will be described later. Here, when the laser beam scanning mechanism is operated after the central position of the bubble 13 is checked, a vertical laser beam line is formed. FIG. 14 shows the process of conversion between a horizontal line and a vertical line.

Referring to FIG. 14, the liquid levelness indicator 13 and the laser beam scanning window 20 are formed at the upper surface and side surface, respectively of the levelness and/or verticality indicator using laser beams according to the present invention. Preferably, the levelness and/or verticality indicator of the present invention includes the upper unit 15 having the remote receiving window 30 formed at the side thereof and the lower unit 15' having a hole 60 in which the tripod 40 is inserted and a groove 55 formed therein along which a cantilever 50 can slide so that the upper unit 15 can be used as a verticality indicator. The hole 60 formed in the lower unit 15' is coupled to the tripod (40 of FIGS. 15 and 16) to rotate the indicator as much as one desires. As an example of such a structure, the tripod and the hole are screw-coupled, and by rotating a rotary disc 65 installed near the hole 60, the levelness and/or verticality indicator on the tripod 40 can be rotated. Also, as another example, the tripod and the hole are screw-coupled and the indicator on the tripod is rotated so that the indicator on the tripod can be placed at a desired position by screwing or unscrewing the screw.

The levelness and/or verticality indicator using laser beams can be efficiently operated because it is installed on the tripod.

FIG. 15 is a perspective view showing a levelness and/or verticality indicator installed on a tripod adopting an automatic reference levelness  
5 maintaining method according to a preferred embodiment of the present invention. FIG. 16 is a perspective view showing a levelness and/or verticality indicator installed on a tripod adopting a manual reference levelness maintaining method according to another preferred embodiment of the present invention. FIGS. 17 and 18 are perspective views showing  
10 examples of the levelness and/or verticality indicator of FIG. 15 applied to a process of laying bricks horizontally or vertically, respectively. FIGS. 19 and 20 are perspective views showing examples of the levelness and/or verticality indicator of FIG. 16 applied to a process of laying bricks horizontally or vertically, respectively.

15 FIGS. 17 through 20 are views for explaining brick laying processes to which horizontal and vertical indication lines formed by the indicator 10 on the tripod 40 are applied. Referring to FIGS. 17 and 18, the indicator 10 automatically maintains a reference levelness by a reference levelness maintaining means using two balls (spherical bodies) positioned in the  
20 outer box 190 under the laser beam scanning mechanism 4 and forming and outputting a laser beam line. Here, the height at which a level line is formed can be controlled by adjusting an angle of the tripod. However, although not shown in the drawings, the horizontal work of FIG. 17 or the vertical task of FIG. 18 can be performed by converting laser beam into  
25 horizontal and vertical laser beam lines through the rotation mechanism of the laser beam scanning mechanism. As shown in FIG. 19, the upper unit 15 and the lower unit 15' of the indicator on the tripod 40 are folded together so that the indicator can operate as the liquid levelness indicator 10. The laser beam scanning mechanism installed inside the indicator  
30 emits a laser beam horizontally through the laser beam scanning window

20 so that a levelness is formed on a wall of laid bricks. Here, the height at which a level line is formed can be controlled by adjusting an angle of the tripod. In FIG. 20, the upper unit 15 and the lower unit 15' are unfolded to make a right angle therebetween so that a vertical laser beam emitted  
5 through the laser beam scanning window 20 is formed at a desired position. That is, in the drawing, the laser beam is formed on a wall of laid bricks as a reference vertical line.

As described above, a camera tripod may be used as the tripod 40 for fixing the indicator 10 depending on the required degree of accuracy.  
10 For a precision product, a special tripod may be used.

In the process of manufacturing the levelness and/or verticality indicator using a laser beam according to the present invention, a fine calibration process should be performed after the laser beam scanning mechanism and the reference levelness maintaining apparatus are set.  
15 The calibration process is described with reference to FIGS. 21A and 21B.

FIGS. 21A and 21B are views for explaining the process of calibration of an accurate levelness in a manufacturing process of the levelness and/or verticality indicator using a laser beam according to the present invention.

20 The indicator is produced by performing an accurate adjustment such that a laser beam emitted at a position where an indicator of a levelness system indicates a levelness with respect to a reference plane at a site of production can have a levelness surface. To check levelness state wherever the levelness indicator is installed, liquid is sealed into a  
25 glass cup parallel to the direction in which the laser beam is emitted. The position in which the levelness of the liquid corresponds to the line indicated on the surface of the glass cup is considered to be parallel. Then, the laser beam can maintain levelness. As indicated by (A) and (B) of FIG. 21A, it is very difficult or nearly impossible to match the heights of  
30 water levelness contained in separate cups. However, as indicated by (C),

(D) and (E) of FIG. 21B, when liquid is filled in a state in which the bottom portions of the respective cups are connected to one another, the heights of the water levels become the same due to the atmospheric pressure. Referring to FIG. 21B, the height of a light source of a laser beam of the indicator 10 is matched to the position of the water level of a water column (D). While the verticality of the laser beam scanning mechanism is maintained, to match the height of the light source of the laser beam to the heights of water levelnesss of the water columns (C) and (D), in the present preferred embodiment, the angle of the cylindrical lens (the position and angle of the polygonal rotary mirror in the other embodiment) is finely adjusted. Thus, the laser beam emitted from the laser beam scanning mechanism is calibrated to be always the same as the reference levelness.

In addition to the method of visually checking whether the liquid in a glass cup coincides with a straight line indicated on the surface of the glass cup, the levelness can be electronically checked by means of an optical sensor and a position sensor for checking a boundary line between the liquid and a gas space. To form an ideal verticality, the position of the verticality is checked by using the principle of gyrocompass which automatically makes a levelness posture of an airplane as a vertical posture is maintained by an earth top rotation force using a centrifugal force of a motor rotating 20,000 revolutions per minute. Also, a method of automatically maintaining a levelness by compensating for a displacement from the vertical position with respect to the verticality by using servo motors installed at two axes may be adopted.

After calibration of the levelness and/or verticality indicator of the present invention is completed, a user can visually check a levelness state or automatically maintain a levelness wherever it is installed, so that a line made by the laser beam emitted by the levelness indicator can be maintained to be level. The same effect as in indication of verticality using a plumb tied to a string can be obtained by using a rotation mechanism in



the laser beam scanning mechanism of the levelness indicator, for example, by rotating the cylindrical lens or fixing the levelness indicator by making it upright by  $90^\circ$  with respect to a fixing nut portion fixed to the tripod. Thus, the levelness indicator can be used for building any kind of column  
5 or vertical structure.

To expand the application fields of the levelness and/or verticality indicator, emitted laser beam is adjusted to flicker at predetermined intervals. While the laser beam is emitted and simultaneously the rotation speed of the polygonal rotary mirror is changed at a constant speed, the  
10 levelness line indicated by the laser beam is indicated as a dotted line having predetermined intervals. Thus, the central position or distance can be indicated with respect to the number of intervals of the dotted lines between the end portions thereof.

Application examples of the levelness and/or verticality indicator  
15 using a laser beam of the present invention will now be described.

FIGS. 22A and 22B are perspective views for explaining a function of a reflection sheet used for a vertical taskpiece having a large structure. When a vertical task such as a telegraph pole is performed, and the amount of solar radiation is large or an object subject to the vertical task is located  
20 far away, a reflection sheet 220 (a retroreflector sheet) is attached to the object before the task is performed, as shown in FIG. 22A. The reflection sheet consists of glass balls or a triangular plumb attached on the surface thereof for reflecting incident light at an incident angle, as shown in FIG. 22B. By using the reflection sheet 220, task distance can be extended to  
25 several hundred meters. When a laser beam line from the indicator 10 is vertically radiated onto the reflection sheet, the reflected light can be seen even when the laser beam is not visible due to the sunshine during the day time, so that a levelness and/or vertical task can be performed. As shown in the drawing, in the case of fitting the verticality of a power pole, the  
30 verticality of a power pole is adjusted by emitting a laser beam onto the



reflection sheet from one position and a person visually checking the reflected light with their naked eyes. Then, a laser beam is emitted from another position separated by  $90^\circ$  from the first position and the verticality of the power pole is adjusted such that a light reflected from the reflection  
5 sheet can be formed. Thus, the vertical task of the power pole is completed.

When the levelness and/or verticality indicator using a laser beam according to the present invention is used, although seeing a reflected straight light ray of a red laser beam having a wavelength of 650 nm within  
10 a particular output range does not matter, directly seeing a light emitting portion of the laser beam may be dangerous like seeing the sun without wearing eye protection glasses which may cause loss of eyesight. Accordingly, glasses for protecting the eyes of a worker using the laser beam indicator of the present invention or a protection apparatus attached  
15 to a helmet is needed. An eye protection system for protecting a worker's eyes from a laser beam will be described in detail with reference to FIG. 23.

FIG. 23 is a block diagram showing a pair of eye protection glasses for protecting a worker's eyes from a laser beam and an automatic laser beam cut-off circuit. As shown in FIG. 23, to prevent a laser beam emitted  
20 from the laser beam scanning mechanism in the indicator 10 from directly shining in the worker's eyes, an eye protection system consisting of a receiver 230 attached to the indicator 10 and a transmitter 240 attached to a pair of glasses 250 worn by the worker are installed. As shown in the drawing, a laser beam directly shining in the worker's eyes is detected by  
25 a phototransistor 242 in the transmitter 240 of the glasses when a power source 248 supplies electric power. The detected laser beam is processed by an amplification processing portion 244 and is output from an RF transmitter 246 as a control signal for turning off the laser beam. An RF receiver 238 of the receiver 230 in the indicator 10 receives the control  
30 signal and a switching circuit 234 interposed between a pulse control circuit

232 and a laser beam scanning mechanism 236 is operated in response to the received control signal to prevent emission of the laser beam. Although an RF signal is adopted as a control signal, other signals such as an infrared ray signal of 940 nm may be adopted. When such an eye protection system is adopted, the system does not turn off the laser beam when a worker works with his back against the laser beam. However, when a laser beam having a predetermined pulse width is scanned on either side of the glasses or helmet, that is, on a position near the pupil, the above-described RF control signal or an infrared ray control signal is emitted as a laser beam turn-off control signal to prevent the laser beam from being emitted from the laser beam scanning mechanism, so that the worker's eyes can be protected.

Also, the indicator of the present invention can make remote work possible. FIG. 24 is a view for explaining a remote control transmitter and a receiving means for controlling a radiation interval of a laser beam by remotely controlling the levelness and/or verticality indicator using a laser beam of the present invention.

As shown in FIG. 24, the remote receiving window 30 of the present invention is designed so that a laser beam and laser beam radiation intervals can be remotely controlled by using a remote controller 80. In this case, although not shown in the drawing, a processor for generating a control signal for controlling the pulse interval and pulse width of a laser beam by receiving a remote control signal and providing the generated control signal to the modulation circuit 2 of FIG. 3 or to the modulation circuit 22 and the polygonal rotary mirror motor 28 of FIG. 7. Since the above technology is obvious to one skilled in the art, a detailed description thereof is omitted. Here, although the remote control function is described with respect to the indicator of the present invention included in a liquid levelness indicator, since the application thereof to the indicator of the present invention adopting the automatic reference levelness maintaining

apparatus of FIG. 10A is obvious to one skilled in the art, a description thereof is omitted.

Also, work can be more efficiently performed when the indicator of the present invention is placed on a general multi-joint balancing apparatus. FIG. 25 is a view for explaining a case of working while the indicator of the present invention is placed on a multi-joint balancing apparatus. As shown in the drawing, when a multi-joint balancing apparatus 350 is put on the tripod 40 and the indicator 10 is placed on the multi-joint balancing apparatus 350 instead of placing the indicator 10 directly on the tripod 40, the height of the indicator 10 is adjusted by moving each joint. Thus, the height of the indicator 10 can be far more easily and efficiently adjusted by adjusting the multi-point balancing apparatus maintaining balance.

FIG. 26 is a view for explaining a case in which the indicator of the present invention adopts a gyrocompass normally used in an airplane or ship, which may be used as a balance maintaining means of the present invention. As shown in the drawing, the principle of a gyrocompass 450 maintaining a levelness by using the centrifugal force of a motor which rotates at 20,000 revolutions per minute is used. When the gyrocompass 450 is attached to the upper portion of the indicator adopting the automatic reference levelness maintaining apparatus of FIG. 7, a more accurate vertical position is obtained and the deviation from the vertical position is compensated for so that a more accurate levelness can be obtained.

Since the indicator of the present invention is very sensitive to vibrations and impacts, adoption of a structure capable of reducing vibrations and impacts is preferred. FIG. 27 is a view for explaining a structure for absorbing vibrations and impacts on an outer surface of the indicator of the present invention. As shown in the drawing, the outer surface of the indicator 10 of the present invention adopts a honeycomb structure so as to be less affected by wind, vibrations of the ground, or impacts against an object.

As described above, the indicator using a laser beam according to the present invention can easily and accurately form a horizontal line and a vertical line by a laser beam so that productivity in a horizontal and/or vertical task can be improved. Also, an levelness state of the entire structure having a height of hundreds of meters can be recognized. When vertical lines are disposed at two different places and a laser beam is projected on a workpiece, productivity can be improved in all application fields needing a vertical task, such as at sites where a power pole or a steel tower is built, a structure are built by using H beams and steel wires, and an internal column and wood construction is built. That is, when the levelness indicator maintaining a levelness is unfolded at  $90^\circ$  and a beam is radiated, it is easier and more convenient to use, since the same effect is obtained as in the case of obtaining verticality by using a plumb tied to a string. A locking apparatus is provided such that it can be used as a verticality indicator by perpendicularly erecting the levelness indicator and firmly holding it at a right angle. A disc for rotating the levelness and/or verticality indicator by  $360^\circ$  is fixed to the tripod.

FIG. 28 is a view showing a beam emitting mechanism of a laser diode for explaining another preferred embodiment of the present invention. In FIG. 28, a laser beam generating mechanism, includes a modulation circuit 3a for modulating a pulse interval and a pulse width by receiving electrical power from a predetermined power source 2a and a laser diode 6a for emitting a laser beam by being driven according to a modulation signal from the modulation circuit 3a. The laser beam diverging from the laser diode 6a is concentrated by a collimating lens described later and a linearly proceeding laser beam is generated.

In the laser diode 6a, since the width of a combined area 8a formed by depositing a P type semiconductor and an N type semiconductor is very narrow, the laser beam diverges at about  $40^\circ$  in the combined area 8a toward each of combined surfaces of the P type and N type semiconductors

at both sides. The laser beam has a beam divergence of about  $10^\circ$  toward a portion where the P type and N type semiconductors do not contact each other. Thus, a laser beam having a section 10a of an oval shape, whose length is in the same direction in which the P type and N type semiconductors are deposited, is divergent.

That is, since the section 10a of the divergent laser beam forms an oval shape whose length is in a direction in which the P type and N type semiconductors are deposited, some of the divergent beam does not pass through the collimating lens 40a but through portions A and B disposed above and below the collimating lens 40a, as shown in FIG. 29. The divergent laser beam passing through the portions A and B is transmitted through an optical fiber 12a to a particular indication point 15a and passes through a focusing lens 14a so that the laser beam can be used to indicate a vertical point indicated by the indicator of the present invention described later at a position separated a predetermined distance from the laser diode 6a without a separate laser diode.

The divergent laser beam emitted from the laser diode 6a is concentrated by the collimating lens 40a disposed at a position separated a predetermined distance from the laser diode 6a, that is, a focal distance, so that a parallel laser beam can be output in a certain direction.

However, in a chip bonding process in which a semiconductor chip of a laser diode is attached to a package during the production process of the laser diode 6, since it is nearly impossible to perform bonding to make the center angle of the beam divergence angle coincide with (perpendicular to) the package, all laser diodes are bonded within an allowed error angle and produced. Thus, the beam divergence center angle of each of the produced laser diodes appears to be difference from each other. About 99% of actually produced laser diodes have different beam divergence center angles.

FIG. 30 is an exploded perspective view of a laser engine optical



portion to make the center angle of a divergent beam coincide with a lengthwise direction of a cylindrical case of a laser engine. FIG. 31 is a sectional view of the laser engine optical portion of FIG. 30. Here, the same structural elements having the same functions have the same  
5 reference numerals.

When the center axis of a laser beam generated by the laser diode 50a does not coincide with the center axis of the collimating lens 40a and the center angles thereof are different, to make the divergent beam a parallel beam focused by the collimating lens 40a, an installation angle of  
10 the laser diode 50a in a hardware structure of the laser engine is corrected so that the respective center angles can coincide with each other.

Here, as a method of correcting an error of deviation of the center angle of a divergent beam of the laser diode of the present invention, the laser diode 50a is inserted in a support plate 52a having a center hole and  
15 three screw holes at the edge thereof. Three dish springs 53a through 55a and a semispherical ring 56a are sequentially inserted around a front portion of the laser diode 50a. Next, the laser diode 50a is pushed to closely contact a guide 60a for supporting the laser diode 50a installed inside a cylinder 58a of the laser engine. Then, the laser diode 50a can be  
20 tilted in all four directions by adjusting three point adjustment bolts 62a screw-coupled to the holes of the support plate 52a and the supporting guide 60a .

Thus, deviation of the center angle of a laser beam unavoidably generated during chip bonding of the laser diode can coincide with the  
25 center line of the collimating lens by adjusting the three point adjustment bolts so that the cylinder of the laser engine and the laser beam can be made parallel to each other.

In FIG. 32, the center of a cylinder of the laser engine of the laser diode and a radiating angle of a laser beam do not coincide with each  
30 other. In FIG. 33, a laser beam output at an angle tilting downward below



the center line is made to coincide with the center line of the cylinder of the laser engine and the collimating lens by adjusting the laser diode to tilt upward by using the adjustment bolts.

FIG. 34 is a sectional view for explaining the pendulum movement of the levelness and/or verticality indicator of the present invention. FIG. 35 is an exploded perspective view for explaining the structure of a gyrohorizon shown in FIG. 34. FIG. 36 is a sectional view showing an intermediary ring and a center ring of the gyrohorizon shown in FIG. 35. FIG. 37 is a plan view of a multiple pole magnet ring shown in FIG. 34. FIG. 38 is a plan view for explaining eddy current generated when a copper plate of FIG. 34 performs pendulum movement above the multiple pole magnet ring.

In FIG. 34, a gyrohorizon 98 is coupled so as to be engaged with pendulum movement of a perpendicularly coupled levelness and vertical laser engine portion 90. A weight plumb adjusting portion 93 for adjusting the center of gravity of the weight plumb 94 is coupled through the levelness and verticality laser engine portion 90 so that a vertical laser engine 86 is disposed vertically by adjusting the position of the weight plumb 94 of a copper plate and a weight adjustment bolt. Thus, the gyrohorizon 98 is integrally engaged with the weight plumb 94 so that, when the pendulum movement of the weight plumb 94 stops levelness, verticality engines 84 and 86 are maintained horizontally and vertically, respectively.

The structure of the gyrohorizon is described in detail with reference to FIGS. 35 and 36.

An intermediary ring 104 having a diameter less than that of an outer ring 102 is inserted in the outer ring 102 by inserting two first shafts 108 through the outer ring 102 and an outer circumferential ring of the intermediary ring 104 along a straight line of the X axis piercing the rings 102 and 104 in a diametric direction. The intermediary ring 104 has a

bearing 110 inserted therein and is rotatably coupled by the two first shafts 108. Thus, the intermediary ring 104 is stable in the fixed outer ring 102 and performs pendulum movement to the right and left until it is stopped.

The intermediary ring 104 is coupled by a second shaft 110b to a  
5 center ring 106 having a diameter less than that of the intermediary ring 104 in the same manner of rotatably coupling the outer ring 102 and the intermediary ring 104 so as to coincide with the Y axis perpendicular to the direction of the first shaft 108.

When a shaft is inserted in the bearing 114 inserted in the center  
10 ring 106 so as to be rotatably coupled to the intermediary ring 104, if an excessive force is applied to the bearing, the life span of the bearing is shortened or the bearing no longer properly functions. A V shaped groove 120b is formed in a portion of the shaft which is fixed without rotation in a state in which no margin is provided between the shaft and the bearing. U  
15 shaped bolts 116 are coupled at the upper portions of the outer ring 102 and the intermediary ring 104 where the fixing shaft is inserted so that the U shaped bolts can be locked at the V shaped groove of the fixing shaft.

Accordingly, movement is possible without margin and application of an excessive force to the bearing and the shaft. Also, when the position  
20 of the levelness/verticality and vertical point indicator of the present invention is changed, the intermediary ring 104 of the gyrohorizon moves in the right and left directions. The center ring 106 moves to the right and left together with the movement of the intermediary ring 104 while performing movement in the forward and backward directions, and finally  
25 stops.

The weight plumb is installed with the levelness laser engine 84 and the vertical laser engine 86 at a lower portion of a vertical air shaft coupled to the inner circumference of the center ring 106. To make the weight plumb rest in the vertical direction after it stops pendulum movement, the  
30 position of a weight plumb correcting bolt 92 provided above the weight

plumb 94 for correcting unbalance of the weight plumb which happens during a processing or assembling step, is adjusted so that the vertical laser engine 86 can accurately direct to verticality. In the case of a gyrohorizon assembled with precision by bearings 112 and 114 on X and Y axes installed at the two rings 104 and 106 and the shaft, the weight 94 coupled to the center ring 106 and extending to be installed at an end of the lower portion performs movement in  $360^\circ$  and directs verticality. However, since the weight plumb 94 stops slowly, it takes a long time for it to be ready for measurement.

Accordingly, as a method of having the weight plumb 94 stop as quickly as possible while maintaining the verticality as a result of pendulum movement, a copper plate is installed under the weight plumb 94 or the weight plumb 94 is formed of a copper plate and a multiple pole magnetic ring 96 shown in FIG. 34 is fixed at the lower portion of the indicator and is separated from the indicator by a predetermined distance. In this case, when the levelness/verticality indicator for indicating the levelness and verticality is positioned at a desired place, when the gyrohorizon 98 moves it is engaged with the weight plumb 94 and the weight plumb 94 performs pendulum movement without frictional resistance. When the weight plumb 94 performs pendulum movement in a direction indicated by an arrow as shown in FIG. 38, eddy currents are generated inside the weight plumb 94 which is a copper plate by a magnetic field generated by the multiple pole magnetic ring 96 which is fixedly installed just under the weight plumb 94.

That is, as the weight plumb 94 performs pendulum movement above the fixed multiple pole magnetic ring 96, a plurality of eddy currents are generated in the weight plumb 94 according to the Fleming's right hand rule. When the thickness of the copper plate is 3 mm or more, these eddy currents enter a state in which the flow of the eddy currents are short-circuited, so that the multiple pole magnetic ring 96 functions as a magnetic brake to restrict movement of the copper plate. Thus, the force of the

magnetic brake increases as the pendulum movement of the weight plumb 94 in the gyrohorizon 98 increases, so that the pendulum movement can be stopped in a short time.

FIG. 39 is a sectional view showing a beam output from the levelness and/or verticality indicator show in FIG. 34, in which the elements corresponding to those in FIG. 34 are indicated by the same reference numerals.

When the vertical laser engine 86 emits a laser beam upward through the cylinder fixed to the center ring 106 of the gyrohorizon 98 of FIG. 34, a beam splitter 144 of a vertical laser beam converting and outputting means transmits some of the laser beam as it is to form a vertical point on the ceiling (not shown) and reflects the other portion of the beam, so that the beam is diverged by a vertical cylindrical lens portion 146, which is a laser beam converting and outputting means on a vertical surface to indicate a vertical line beam. Also, the vertical laser beam converting and outputting means focuses some of the laser beam emitted from a laser diode (not shown) of the vertical laser engine 86 by a lower vertical point focusing lens 148, thus performing a function to indicate a lower vertical point at a position in a vertical direction of the indicator of the present invention. Some of the laser beam is directed to the focusing lens 148 through an optical fiber 141.

In detail, the beam splitter 144 is installed at the upper side of the center shaft of the vertical laser engine 86 and the gyrohorizon 98 to be inclined at a predetermined angle with respect to the center shaft and passes about 20% of the laser beam output from the vertical laser engine 86, upward in the vertical direction, so that a vertical point is formed on the ceiling. Also, the beam splitter 144 reflects the remaining portion of the laser beam output, for example, about 80% of the laser beam output, to the upper vertical point to indicate a vertical laser beam line. The vertical cylindrical lens portion 146 diverges the beam reflected by the beam splitter

144 on the same plane as the vertical surface to indicate a vertical line on a wall. Also, the lower vertical point focusing lens 148 installed at the lower end portion of the outer box 152 of the indicator of the present invention receives the beam output from the vertical laser engine 86 into the optical  
5 fiber 141 to indicate the lower vertical point. The vertical cylindrical lens portion 146 includes a cylindrical lens for diverging the laser beam on the same plane to be described later, a height adjusting means for adjusting the cylindrical lens in the forward and backward directions, and a left and right rotating means for adjusting the left and right inclination angles.

10 The horizontal laser beam converting and outputting means includes a horizontal cylindrical lens portion 143 for receiving a horizontal laser beam output from the horizontal laser engine 84 coupled to the vertical laser engine 86 and diverging the received laser beam on the same plane as the horizontal surface to indicate a horizontal beam line on a wall.

15 The horizontal cylindrical lens portion 143 has the same functions as those of the vertical cylindrical lens portion 146 and includes a height adjusting means for adjusting the cylindrical lens in the forward and backward directions and a left and right rotating means for adjusting the left and right inclination angles of a cylindrical lens for diverging the laser beam  
20 on the same plane to be described later.

Here, the horizontal and vertical cylindrical lens portions 143 and 146 each form cylindrical shapes. As shown in FIG. 30, when the laser beam output from the horizontal laser engine 84 is perpendicularly input to the cylindrical surface of the cylindrical lens 145, the cylindrical lens 145  
25 diverges the input laser beam on the same plane. Here, if the cylindrical lens 145 is fixed to be perpendicular, the laser beam line passing through the cylindrical lens 145 and being diverged is indicated as one horizontal line when being emitted onto a wall.

A fixing means 140b for supporting the levelness and horizontal  
30 indicator of the present invention on a supporter such as a tripod, is



installed at the bottom surface of the outer box 152. The fixing means 140b can be coupled to a tripod by screws.

FIGS. 41 and 42 show the state of divergence of a beam with respect to the angle of the beam perpendicularly input to the cylindrical lens. FIGS. 43 and 44 show the horizontal beam line of a beam with respect to the angle of the beam input to the cylindrical lens to be inclined.

When the beam of the laser engine 84 is perpendicularly incident upon the cylindrical lens as shown in FIGS. 41 and 42, the beam being diverged by the cylindrical lens 145 appears to be linear on a wall surface 160b. In comparison with the above, when the laser beam is incident upon the cylindrical lens 145 tilted backward as shown in FIGS. 43 and 44, the laser beam line being divergent by the cylindrical lens 145 appears on the wall surface 160b as a curve 164 having a middle portion which is curved as much as the cylindrical lens is tilted.

Thus, even when the cylinder of the laser engine is accurately assembled to the vertical shaft, if the laser beam is not perpendicularly incident upon the center portion of the cylindrical lens 145, the middle portion of the beam line appearing on the wall surface 160 is curved as shown in FIG. 44. Thus, the position of the cylindrical lens 145 needs adjustment to accurately indicate the horizontal beam line.

FIGS. 45 and 46 are sectional views showing the structure of a housing of the cylindrical lens for adjusting the position of the cylindrical lens of the laser beam of the present invention.

The housing of the cylindrical lens includes an adjustment means for adjusting the height of the cylindrical lens 145 in the forward and backward directions by two bolts 180b and 182b installed at the housing of the cylindrical lens 145, and a left and right rotating means for adjusting the angle by screwing a bolt 190b in the left and right directions which is installed at the housing of the cylindrical lens 145, to adjust the cylindrical lens 145 to be accurately perpendicular to the input laser beam.

Bending of the horizontal or vertical laser beam line, appearing on the wall by being diverged on the same plane of the horizontal or vertical surface of the cylindrical lens 145, is prevented by adjusting the bolts 180b and 182b which are installed at the housing of the cylindrical lens 145 as shown in FIG. 45 to adjust the height of the cylindrical lens 145 in the forward and backward directions indicated by arrows E and F.

Also, as shown in FIG. 46, by rotating the cylindrical lens 145 in the directions indicated by arrows C or D, that is, to the anti-clockwise or clockwise, by screwing a left and right adjustment bolt 190b installed at the housing 190 of the cylindrical lens 145, the laser beam is divergent on the same plane as the horizontal or vertical surface to match the horizontal or vertical line. Since the above structure is a technology applied to a general camera lens assembly which is well known to one skilled in the art, a detailed description thereof will be omitted.

15

#### Industrial Applicability

As described above, in the levelness and/or verticality indicator using a laser beam according to the present invention, since a tripod is attached to the bottom of the levelness and/or verticality indicator using a laser beam and a remote receiving apparatus is installed at the side surface of the main body of the indicator to enable remote control, use thereof is convenient. Also, a built-in rotation mechanism enables conversion between a levelness indicator and a verticality indicator. The pendulum movement of a weight plumb is stopped quickly due to magnetic resistance so that the real levelness and verticality and a vertical point are convenient are indicated by using a laser beam. Thus, the present invention can reduce the time and amount of work needed for indicating levelness and/or verticality. Further, when an object to be worked on is huge, levelness and/or verticality can be effectively indicated.

30

What is claimed is:

1. A levelness and verticality indicator for indicating levelness and verticality by using a laser beam, the indicator comprising:
  - a laser beam scanning mechanism for emitted a laser beam;
  - 5 means for converting the laser beam emitted by the laser beam scanning mechanism to a laser beam line and outputting the laser beam line; and
  - a reference levelness maintaining means for supporting the laser beam line to be output while keeping the levelness.
- 10 2. The indicator as claimed in claim 1, wherein the laser beam scanning mechanism comprises:
  - a modulation circuit for modulating a pulse interval and pulse width in response to a received predetermined electric power; and
  - 15 a laser diode for emitting a laser beam in response to a modulation signal received from the modulation circuit.
3. The indicator as claimed in claim 1 or 2, wherein the laser beam line converting and outputting means is a cylindrical lens which is  
20 partially cut-processed in a lengthwise direction so that a focused laser beam is converted to a laser beam line.
4. The indicator as claimed in claim 3, wherein the laser beam converting and outputting means further comprises means for rotating the  
25 cylindrical lens by 90° so that the laser beam line is output in a state of being rotated by 90°.
5. The indicator as claimed in claim 1 or 2, wherein the laser beam line converting and outputting means comprises:  
30 a polygonal rotary mirror rotating at a predetermined speed for

reflecting the laser beam so that the focused laser beam is converted to a laser beam line; and

a motor for rotating the polygonal rotary mirror at a predetermined speed.

5

6. The indicator as claimed in claim 1 or 2, wherein the reference levelness maintaining means comprises:

an upper spherical body which is partially cut-processed to accommodate the laser beam scanning mechanism;

10 a support body having a micro bearing means formed on the upper surface thereof so that the upper spherical body is accommodated on three points; and

a lower spherical body having a diameter greater than that of the upper spherical body and coupled to the upper spherical body by the support body, so that balance in a vertical direction is automatically maintained and accordingly the levelness of the laser beam scanning mechanism of the upper spherical body is maintained.

7. The indicator as claimed in claim 1 or 2, wherein the reference levelness maintaining means is a liquid levelness indicator in which a built-in laser beam scanning mechanism for scanning a laser beam through a laser beam scanning window formed at one side of the reference levelness maintaining means is installed at a particular space in the liquid levelness indicator, and the levelness of the laser beam scanning mechanism installed in the liquid levelness indicator is manually adjusted according to the position of a bubble in the liquid levelness indicator.

8. The indicator as claimed in claim 7, wherein the levelness indicator includes an upper unit and a lower unit, and when the indicator is used as a levelness indicator, the upper unit and the lower unit are folded

30

with respect to each other and a cantilever connected to the upper unit slides along a groove formed on the upper surface of the lower unit and is folded, and when the indicator is used as a verticality indicator, the upper unit and the lower unit are unfolded with respect to each other and the  
5 cantilever slides along the groove and is unfolded.

9. The indicator as claimed in claim 1 or 2, further comprising a tripod connected to a hole formed at the lower surface of the indicator for adjusting the height of the indicator to form a horizontal line and a vertical  
10 line of a laser beam.

10. The indicator as claimed in claim 1 or 2, further comprising:  
a window formed at one side of the indicator for receiving a remote control signal from a remote controller; and  
15 a processor installed in the indicator for processing the remote control signal to provide the processed remote control signal to the laser beam scanning mechanism.

11. The indicator as claimed in claim 1 or 2, further comprising an  
20 eye protecting circuit for cutting off the electric power of the laser beam scanning mechanism in response to a power cut-off control signal received from a transmitting portion for transmitting a control signal for cutting off the electric power of the laser beam scanning mechanism when it detects the laser beam line.

25

12. The indicator as claimed in claim 1 or 2, wherein the transmitting portion is installed in a pair of glasses or a helmet worn by a worker to protect the eyesight of the worker.

30 13. The indicator as claimed in claim 12, wherein the reference



levelness maintaining means comprises:

a cylindrical floating body having a deck provided at an upper portion thereof for accommodating the laser beam scanning mechanism;

5 a calibrator including weight plumbs at three points on the deck placed on the upper portion of the floating body, a rod connecting the weight plumbs, and an adjustment plumb for adjusting the levelness of the laser beam scanning mechanism by moving along the rod shape;

a pipe vertically formed in the floating body and in which batteries are inserted;

10 a spherical plumb connected at the lower end of the through hole; and

an outer box containing liquid on which the floating body floats while the spherical plumb is connected.

15 14. A levelness and verticality indicator using a laser beam comprising:

a gyrohorizon fixed at the upper portion of an outer box body and having a central portion capable of rotating and moving in all directions;

20 a weight plumb means hanging from the central portion of the gyrohorizon and performing pendulum movement;

a levelness and verticality laser engine engaged with the weight plumb means and emitting a laser beam in horizontal and vertical directions;

25 a levelness and verticality laser beam converting and outputting means engaged with the weight plumb means and diffusing and outputting the laser beam emitted from the levelness and verticality laser engine to the same plane as a horizontal or vertical surface; and

a swing dampening portion for quickly dampening the pendulum movement of the weight plumb means to a stable vertical position.

15. The indicator as claimed in claim 14, wherein the levelness and vertical laser engine comprises:

a modulation circuit for modulating pulse interval and pulse width in response to a predetermined electrical power;

5 a laser diode for emitting a laser beam by being driven by a modulation signal from the modulation circuit; and

a collimating lens for focusing the diffused laser beam.

16. The indicator as claimed in claim 14, wherein the levelness  
10 and vertical laser beam line converting and outputting means comprises a cylindrical lens which diffuse the vertically input laser beam to the same horizontal or vertical surface as the circular sections of the cylindrical lens and outputs the diffused laser beam as a laser beam line.

15 17. The indicator as claimed in claim 14, wherein the levelness and vertical laser beam line converting and outputting means further comprises:

a height adjusting means for adjusting the height of the cylindrical lens in the forward and backward directions; and

20 a left and right rotating means for adjusting a degree of inclination to the left or right side.

18. The indicator as claimed in claim 14, wherein the weight plumb means is a copper plate.

25

19. The indicator as claimed in claim 14, wherein the weight plumb means further comprises a weight plumb adjusting portion for adjusting movement of the center of gravity of the weight plumb.

30 20. The indicator as claimed in claim 19, wherein the weight

plumb adjusting means adjusts the center of weight by adjusting the position of a bolt.

21. The indicator as claimed in claim 14, wherein the swing  
5 dampening portion is a multiple pole magnet ring which is fixedly arranged at the lower portion of the outer box and separated from the weight plumb means to be vertically thereunder.

22. The indicator as claimed in claim 14, wherein the vertical laser  
10 beam line converting and outputting means further comprises:

an optical fiber for receiving a laser beam emitted from the vertical laser engine and passing through a collimating lens and outputting the laser beam in a vertically downward direction, and a focusing lens for collecting the laser beam transmitted through the optical fiber and  
15 displaying a vertical point on the bottom surface where a body of the outer box is located.

23. The indicator as claimed in claim 14, wherein the gyrohorizon comprises:

20 an outer ring fixed to the upper portion of the outer box;  
an intermediary ring arranged inside the outer ring and rotatably installed by being coupled to the outer ring via a bearing shaft in a radial direction; and

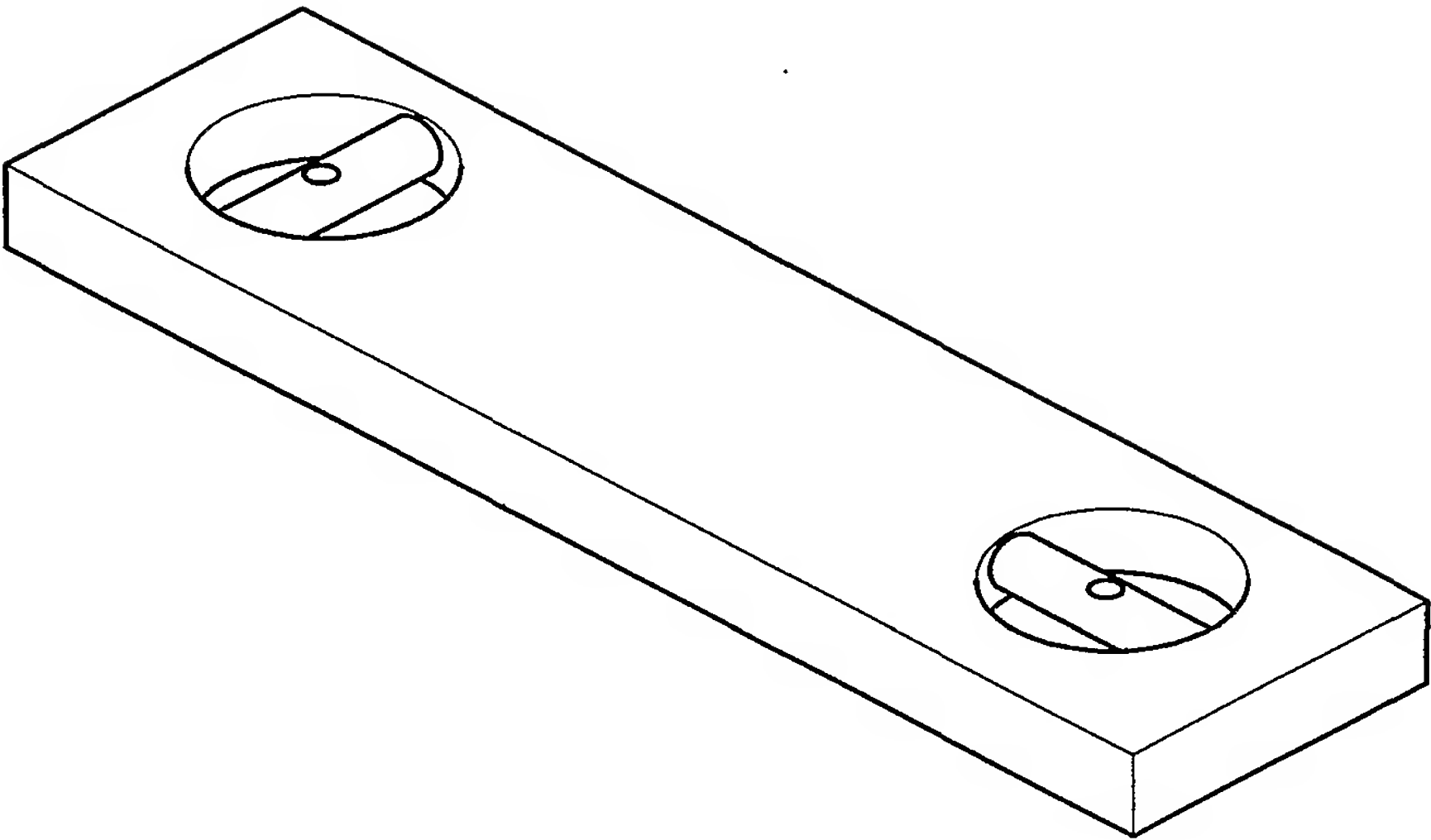
a center ring arranged inside the intermediary ring and coupled to  
25 the intermediary ring via the bearing shaft to be capable of rotating in a direction perpendicular to a direction that the intermediary ring rotates,

wherein the inside of the center ring is coupled to the weight plumb means to be engaged with each other.

30 24. The indicator as claimed in claim 14, wherein the vertical laser

beam line converting and outputting means comprises a beam splitter for transmitting some of a laser beam emitted from the vertical laser engine in an upward direction to display a vertically upper point, and reflecting the remaining laser beam toward the vertical cylindrical lens to display a  
5 vertical line.

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**FIG. 1**



**FIG. 2**

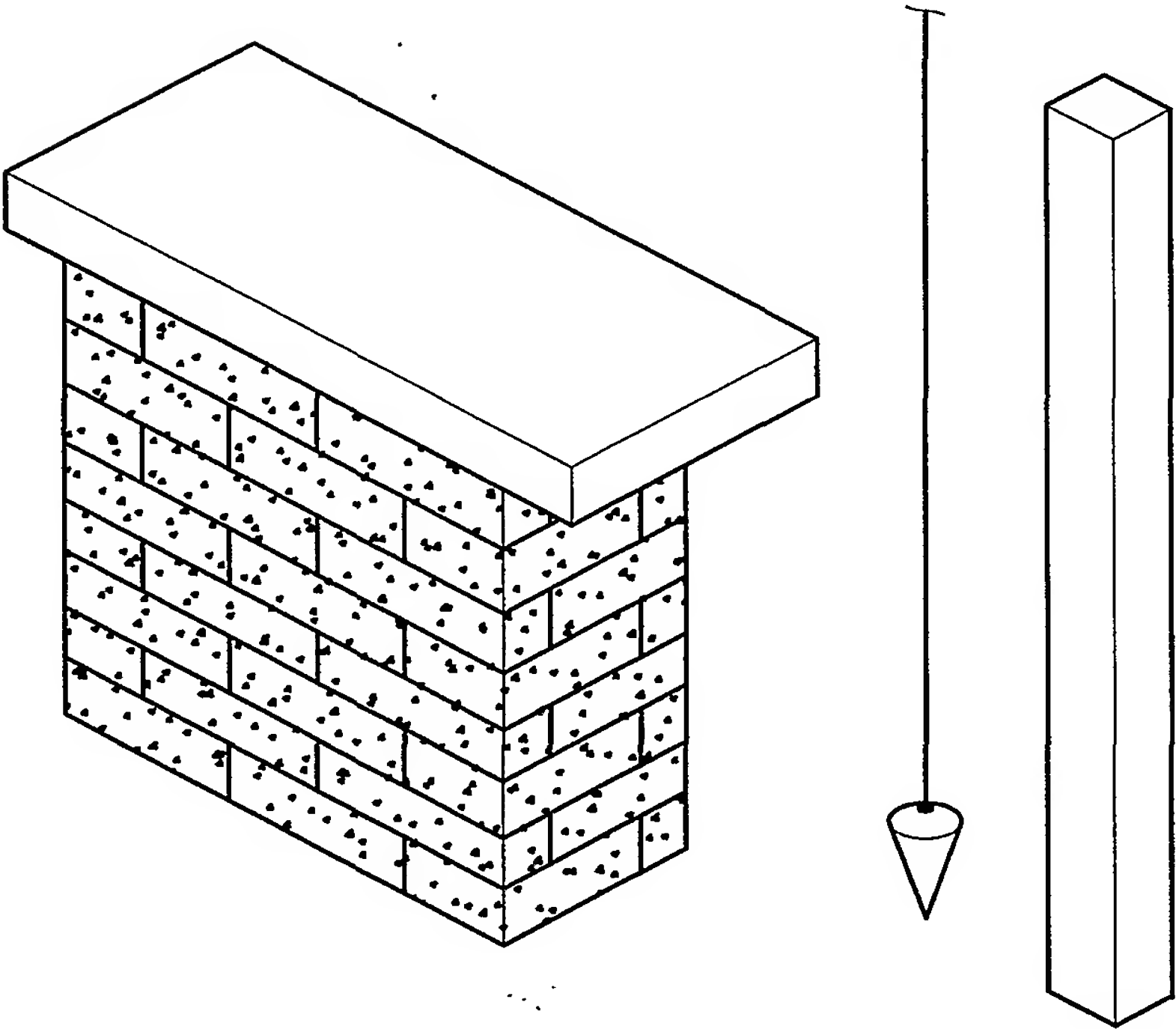




FIG. 3

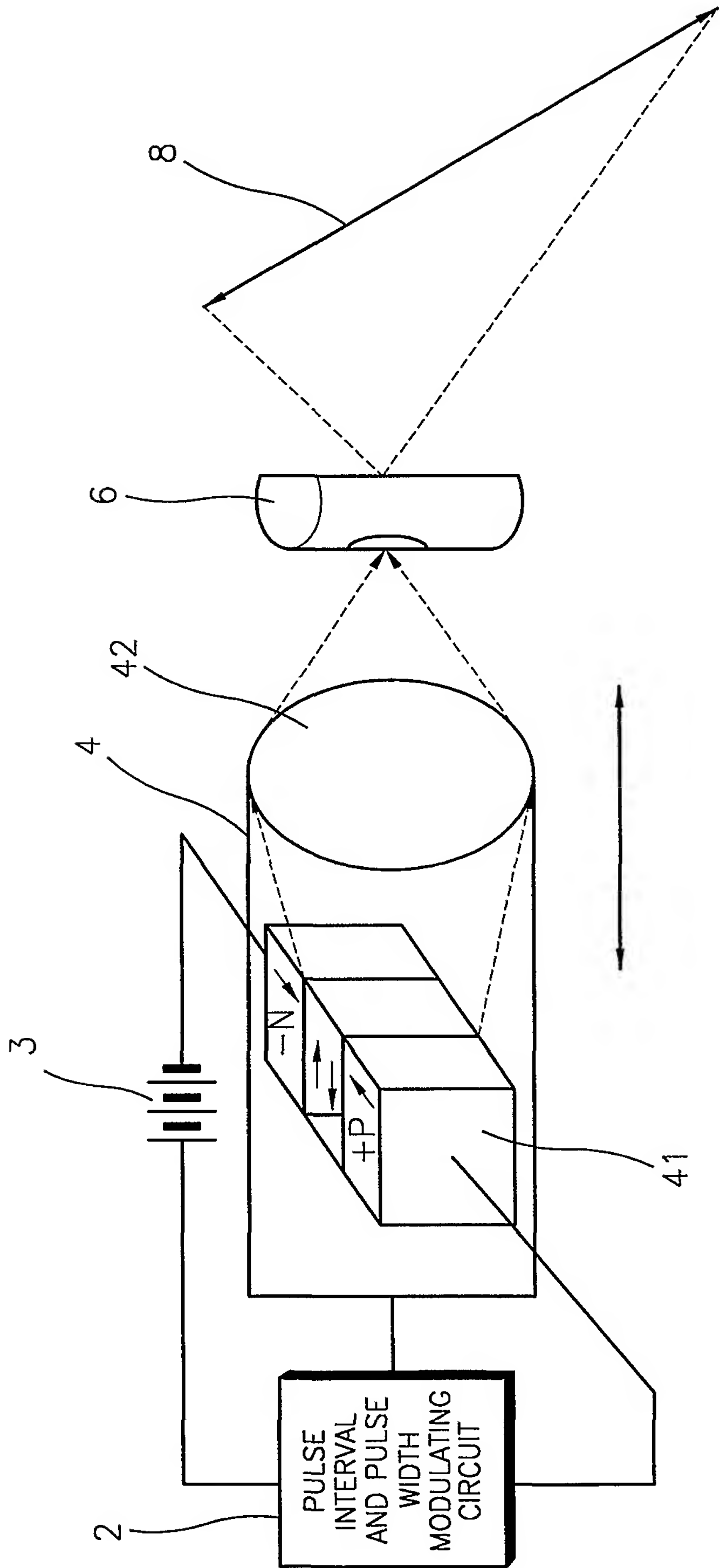
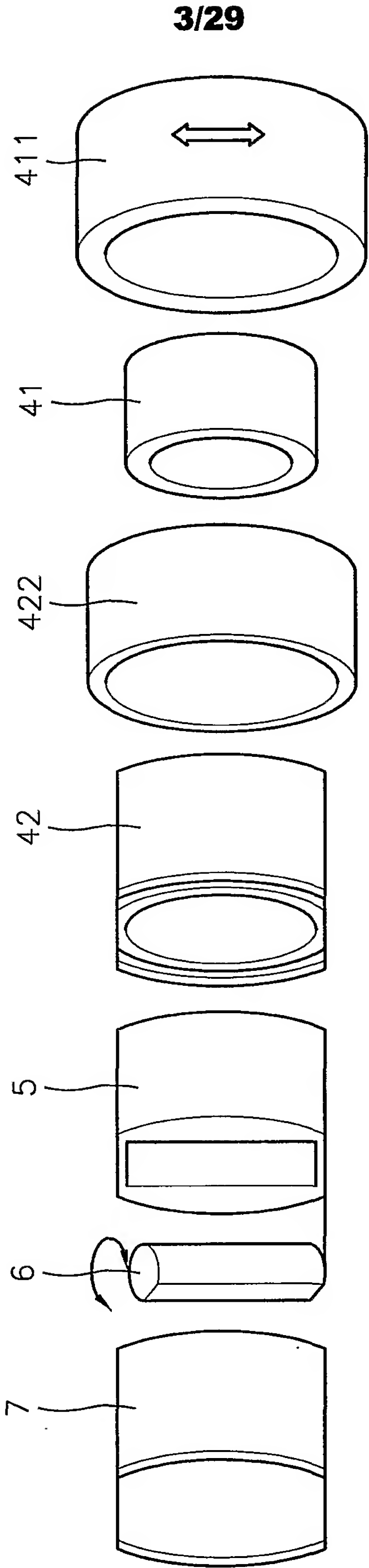
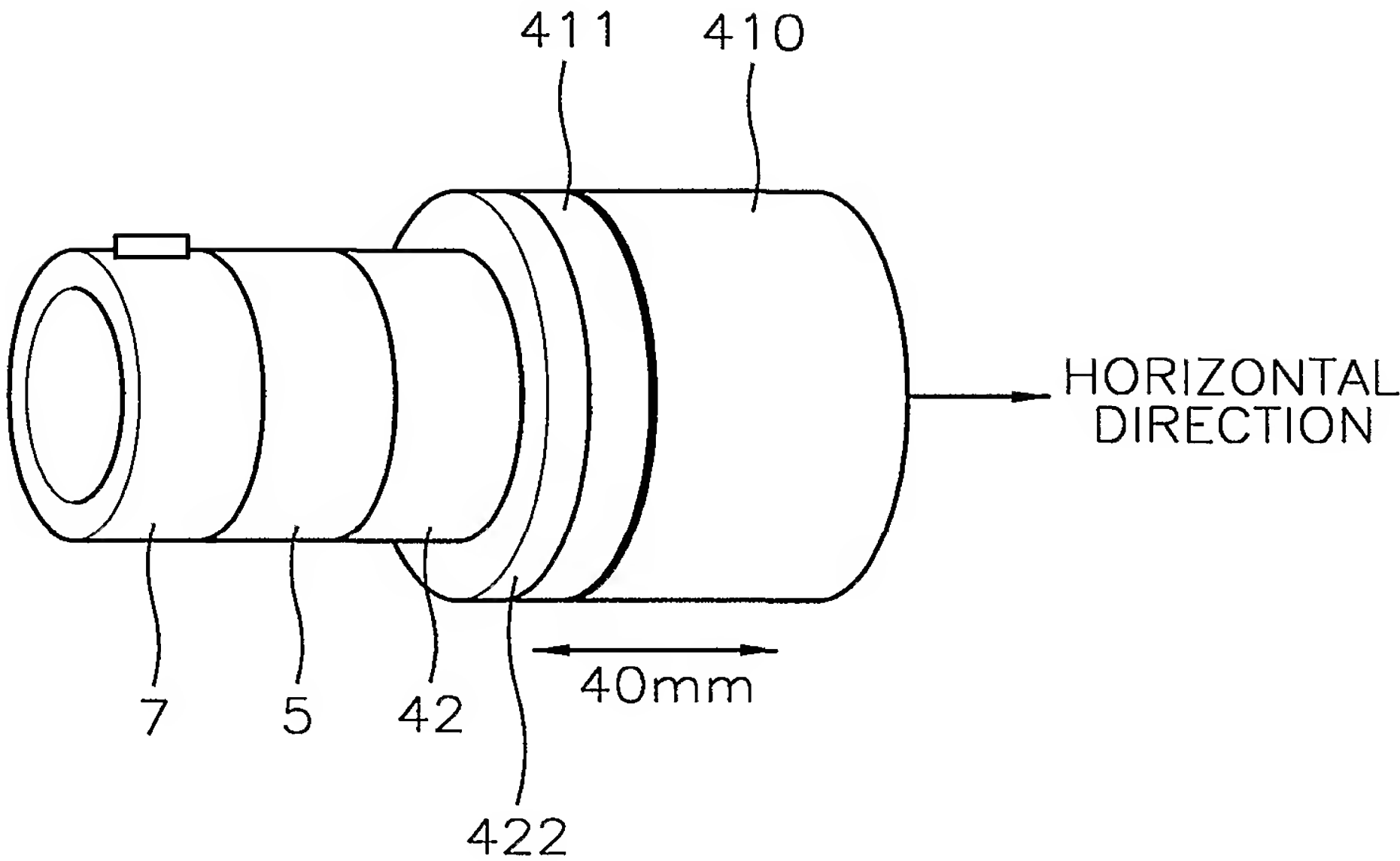


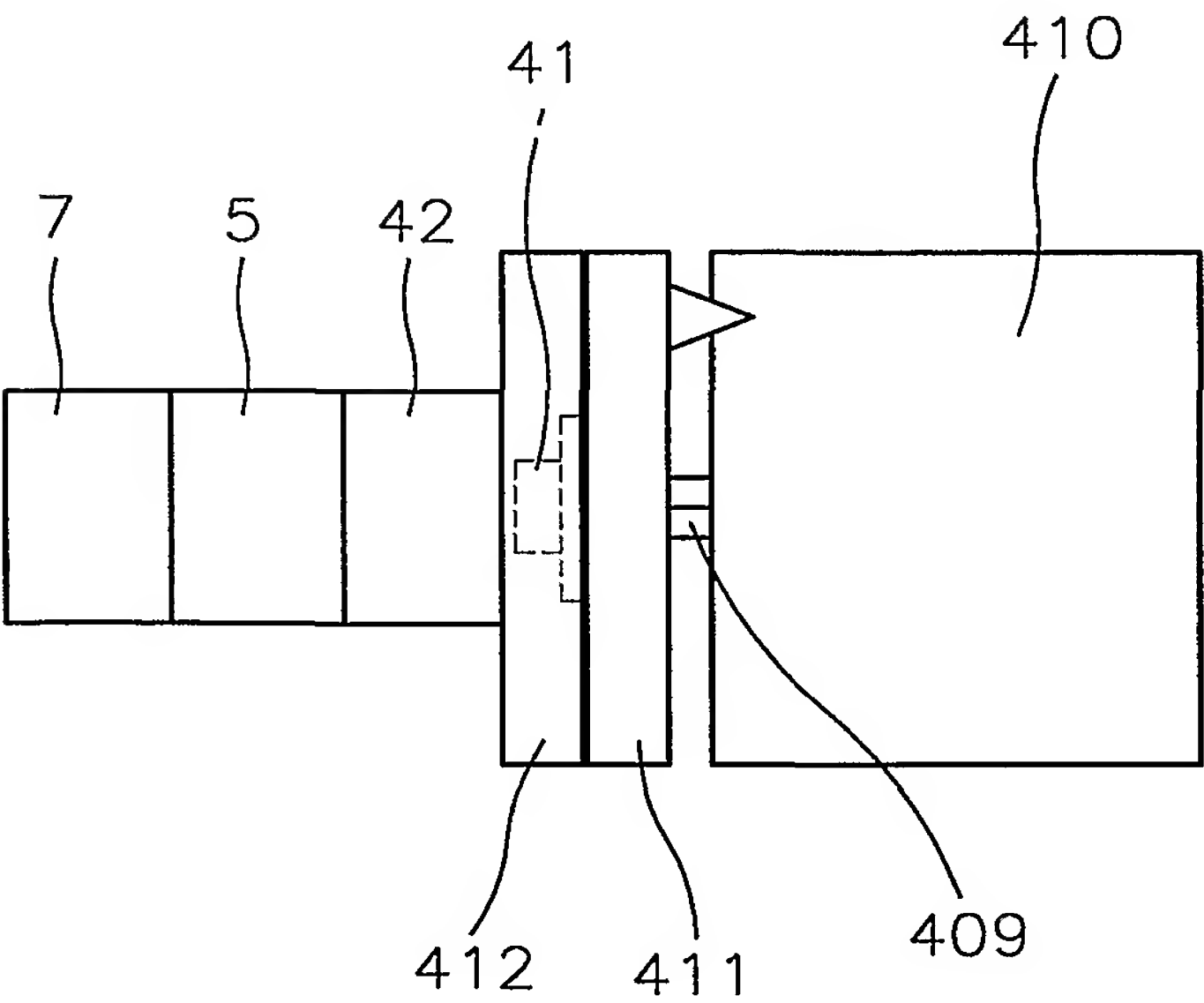
FIG. 4



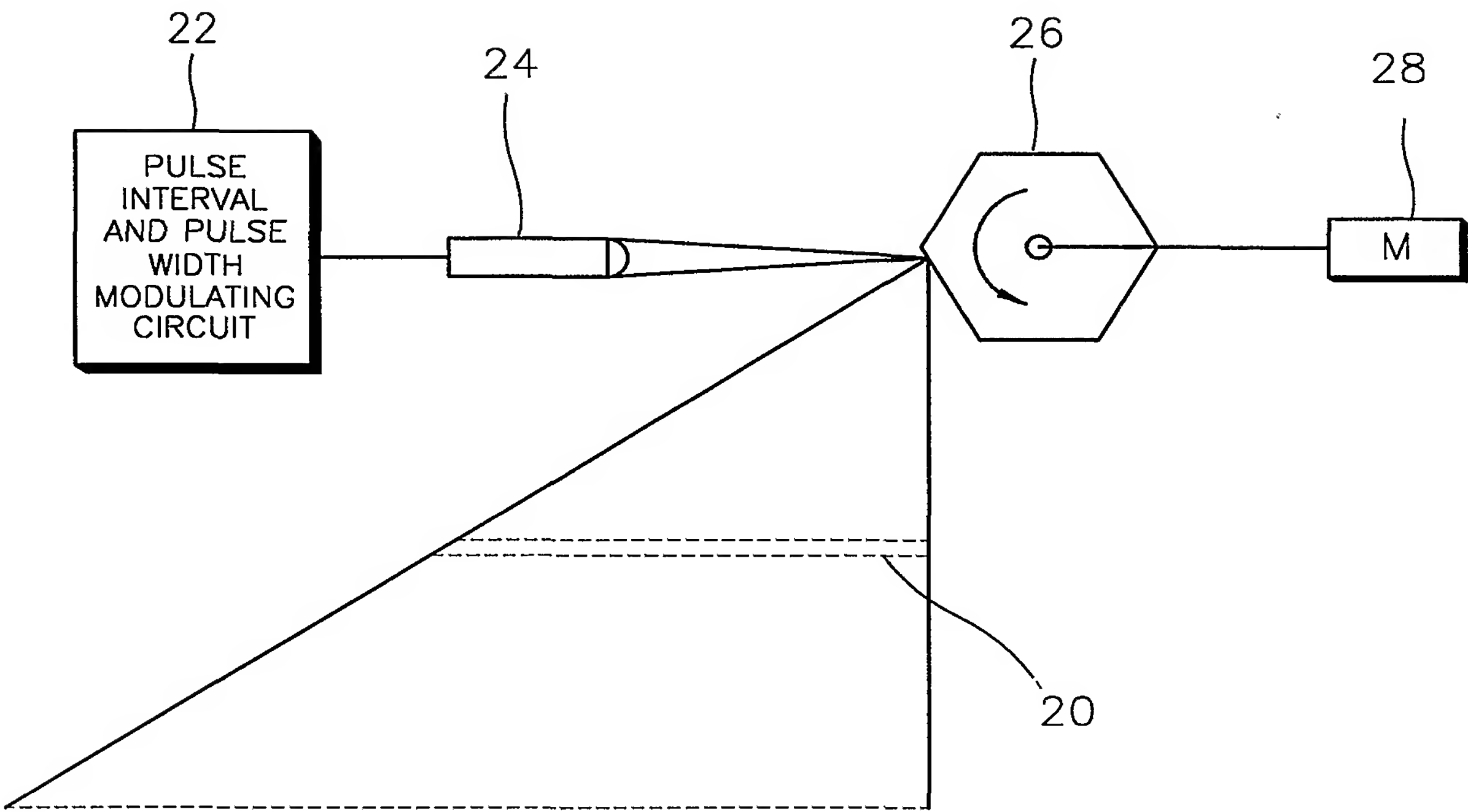
4/39  
**FIG. 5**



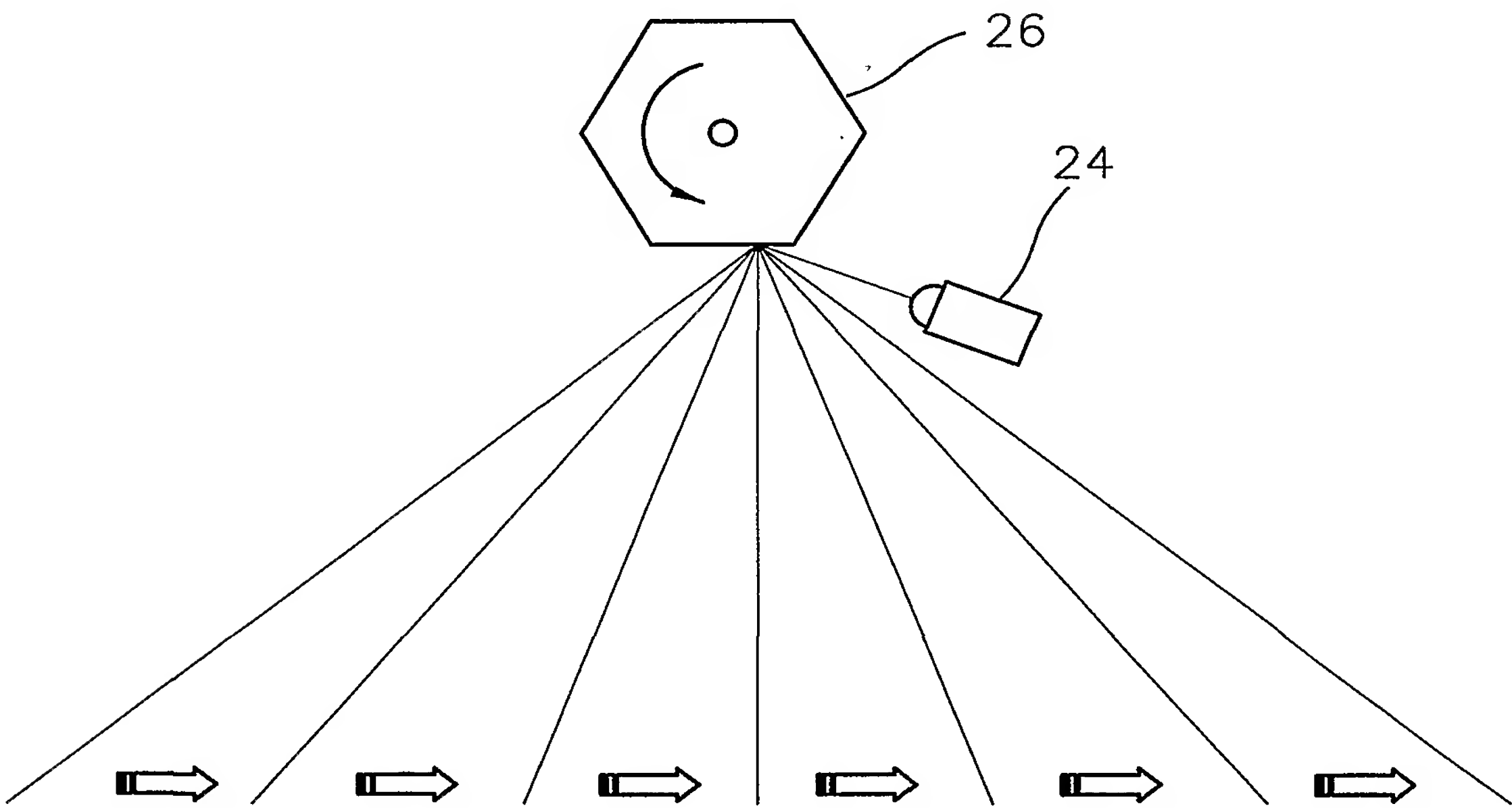
**FIG. 6**



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**FIG. 7**

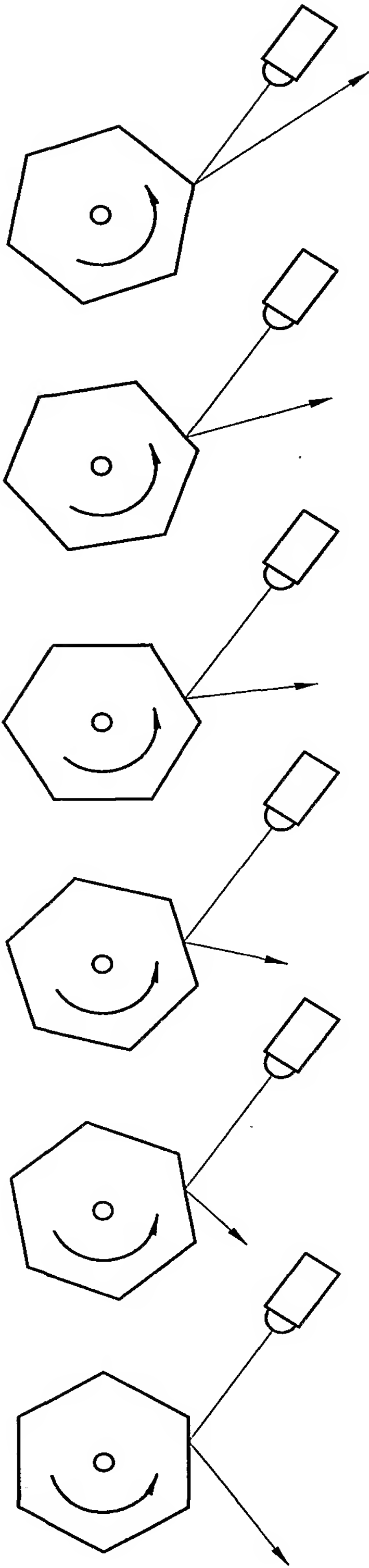


**FIG. 8**



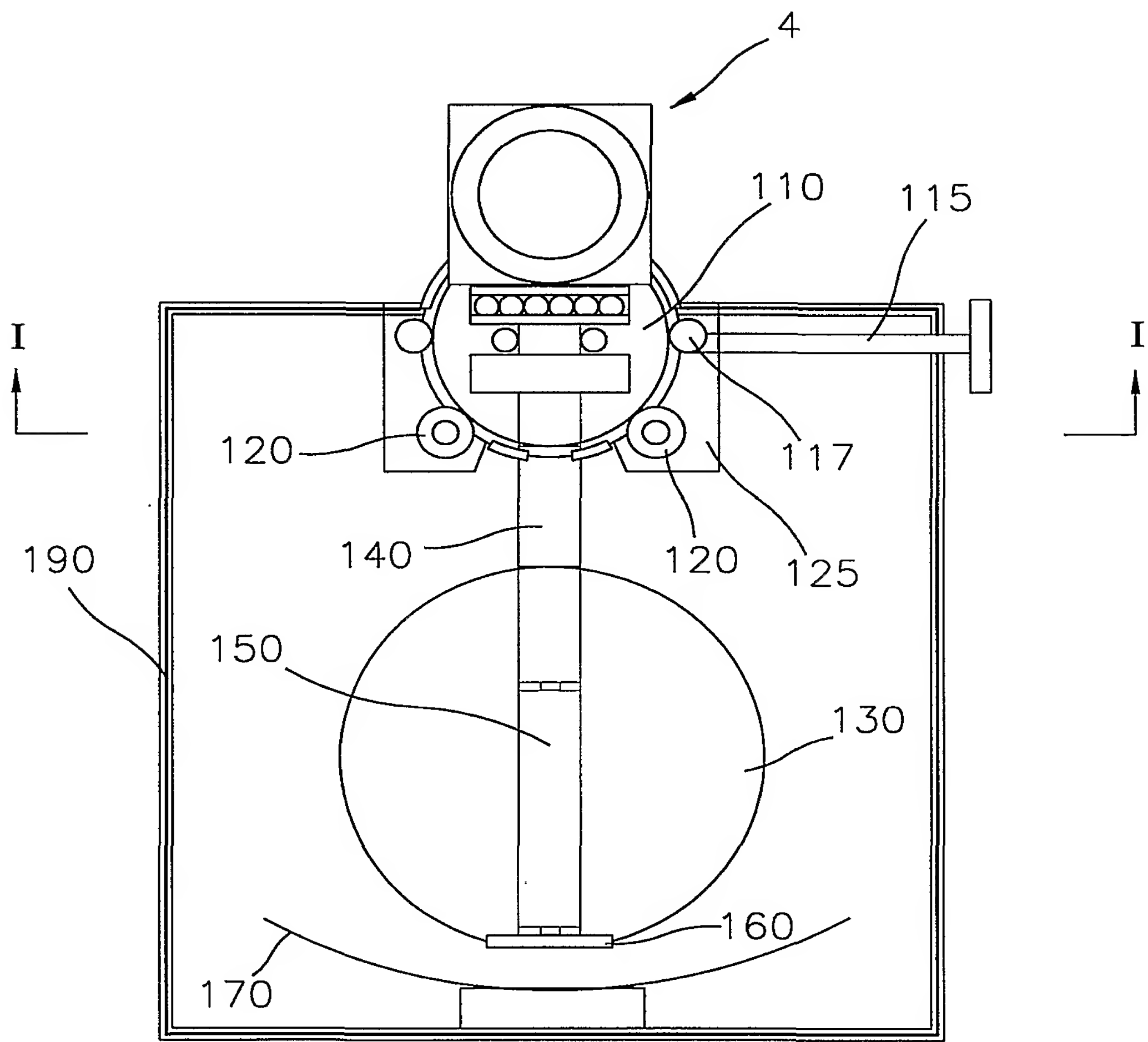
6/29

FIG. 9

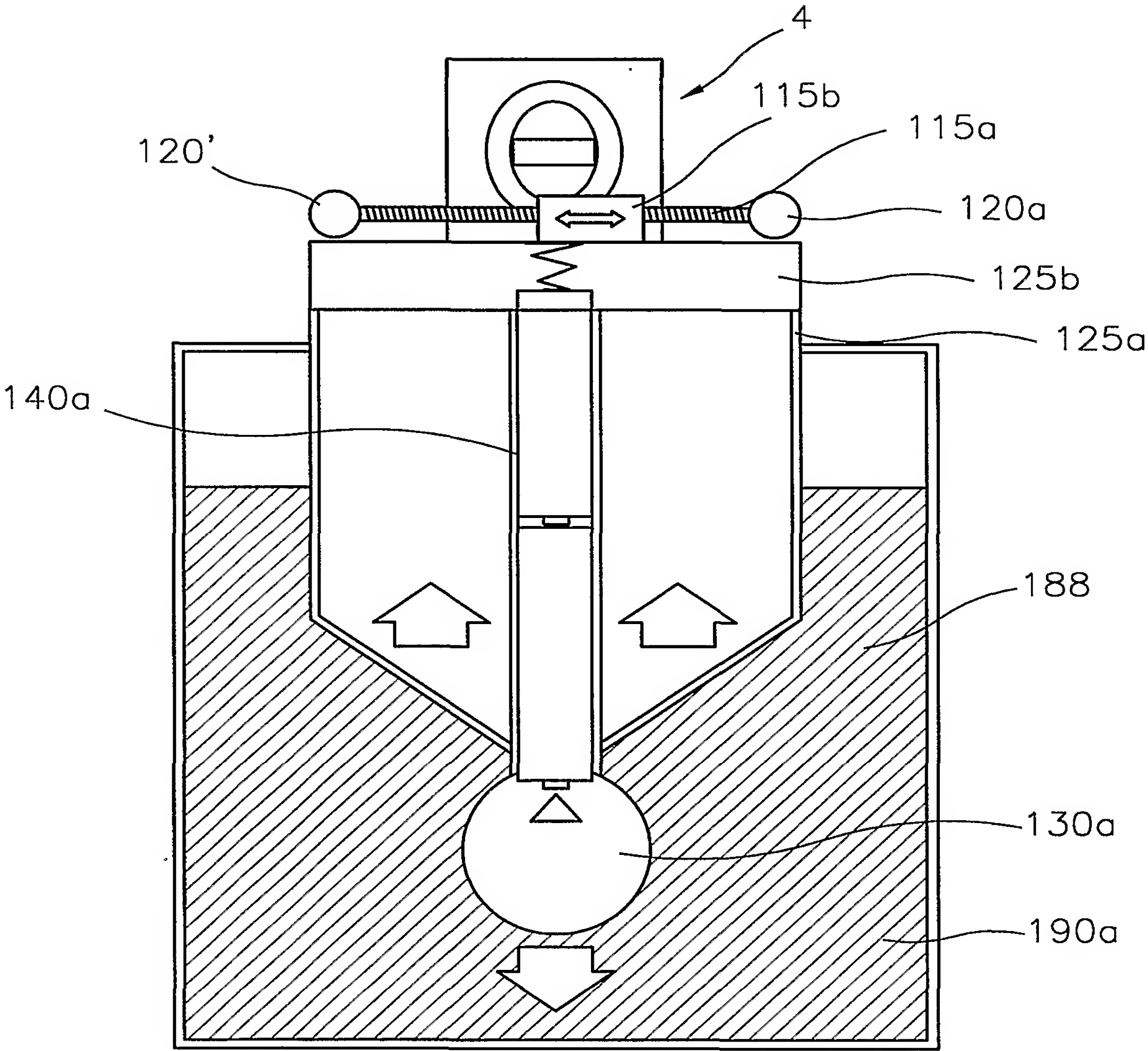




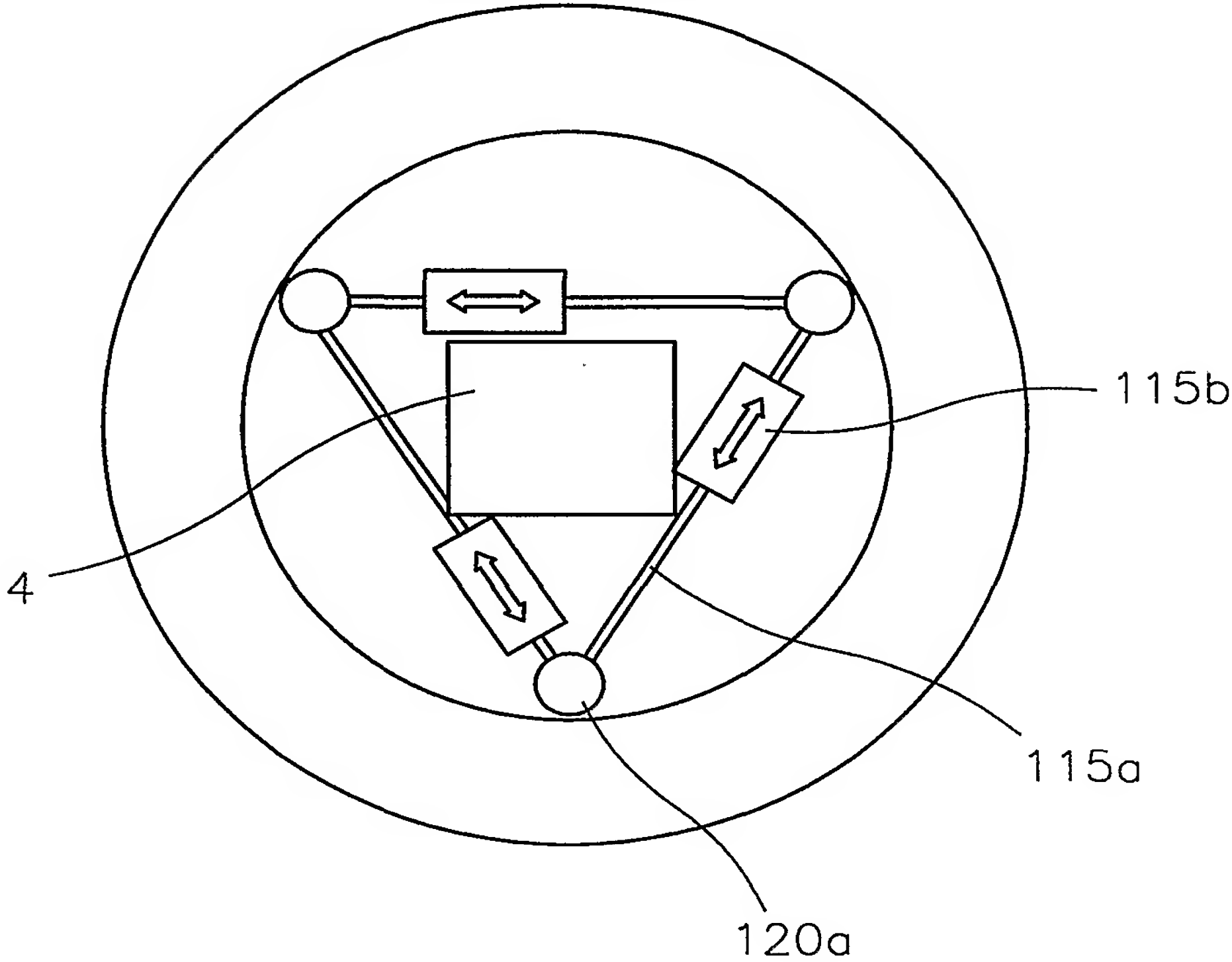
7/39  
**FIG. 10A**



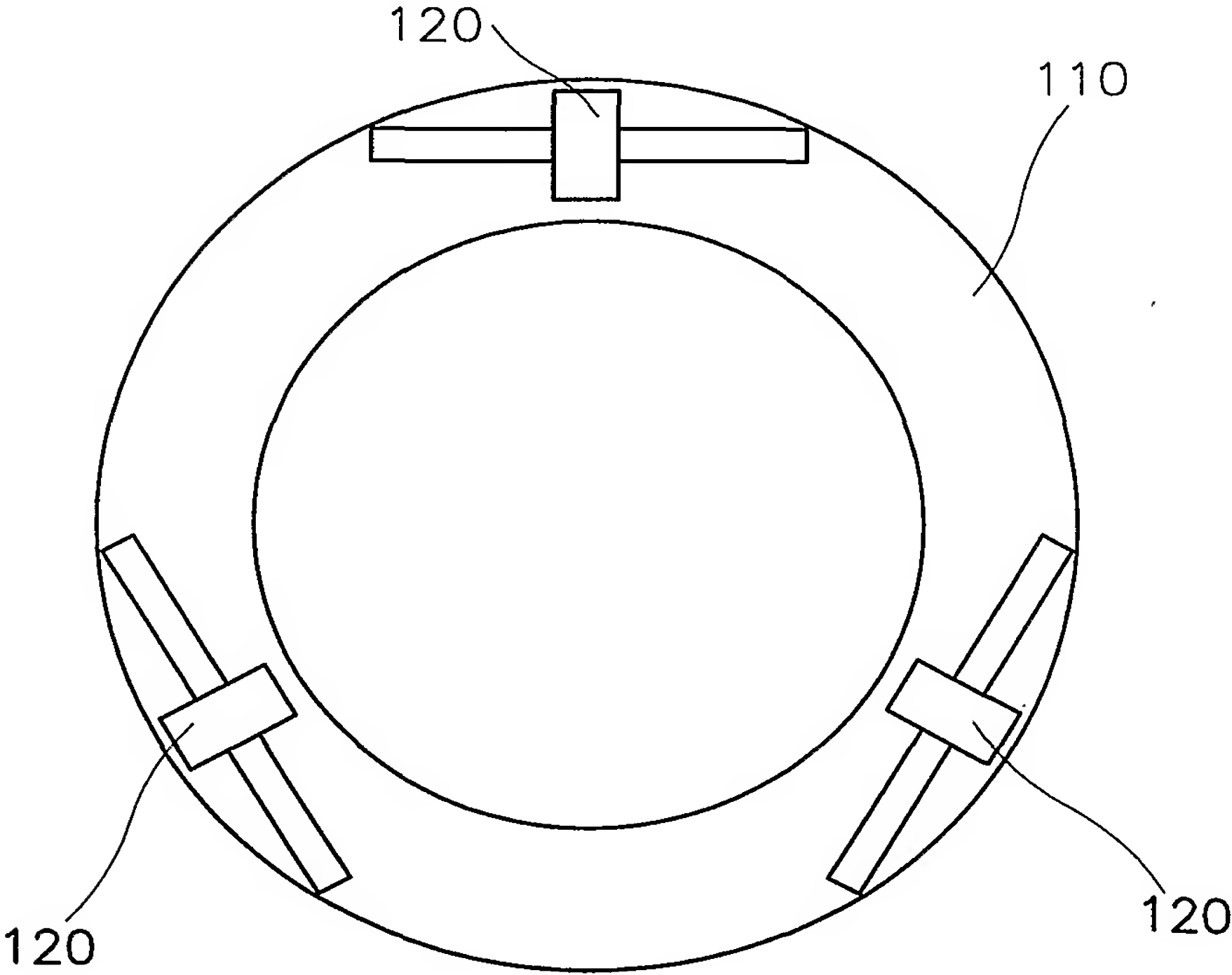
8/39  
**FIG. 10B**



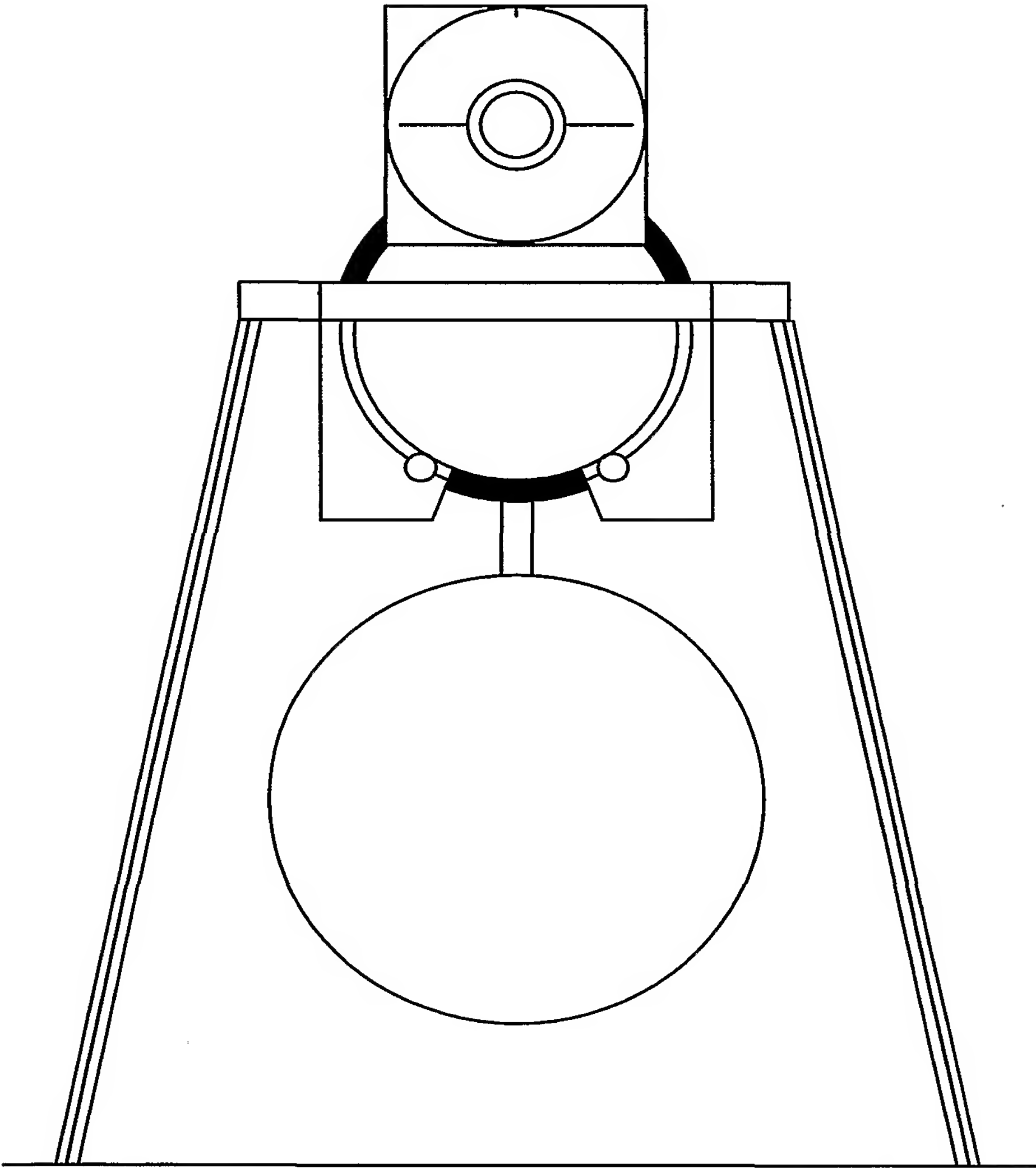
9/39  
**FIG. 10C**



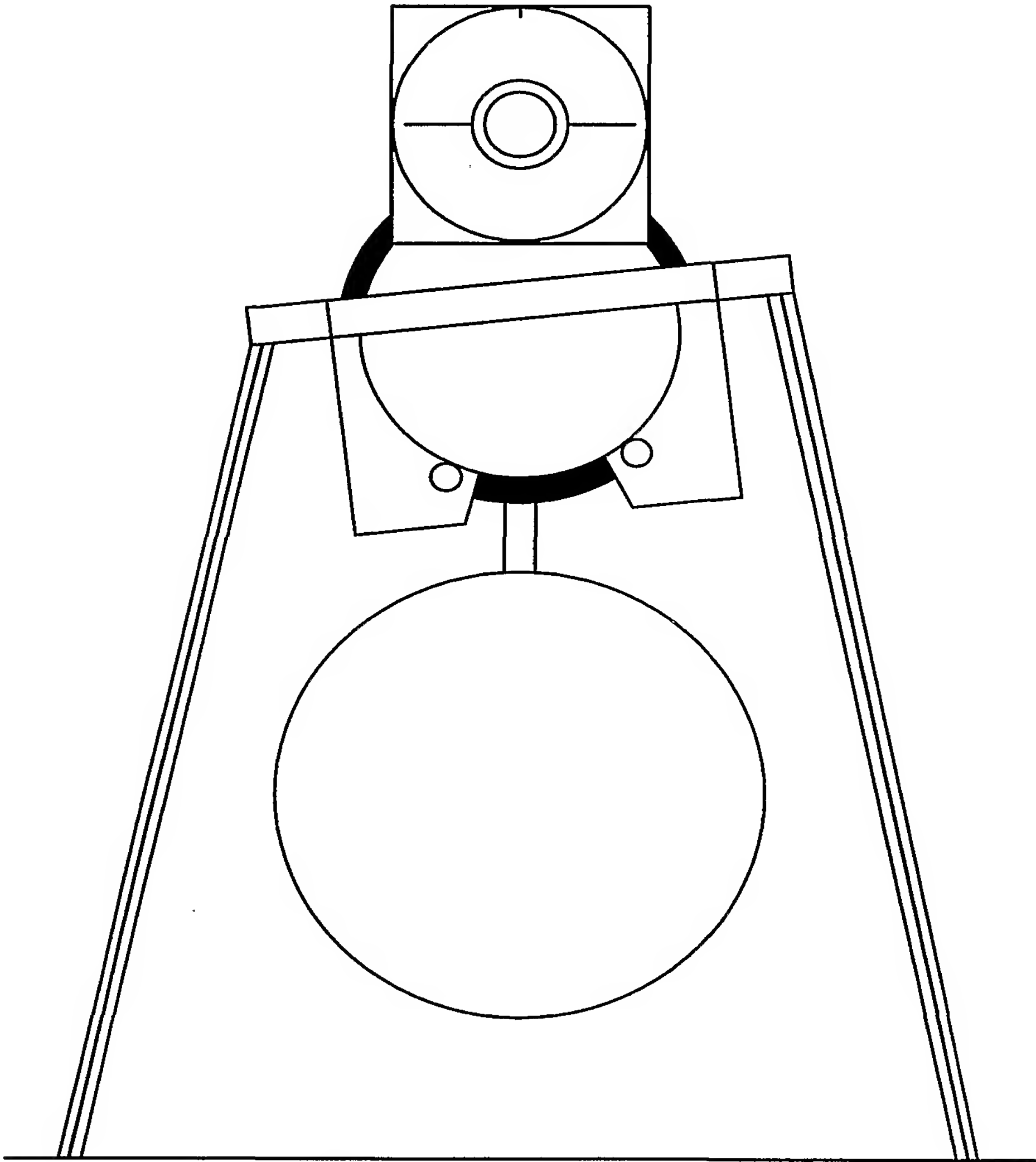
**FIG. 11**



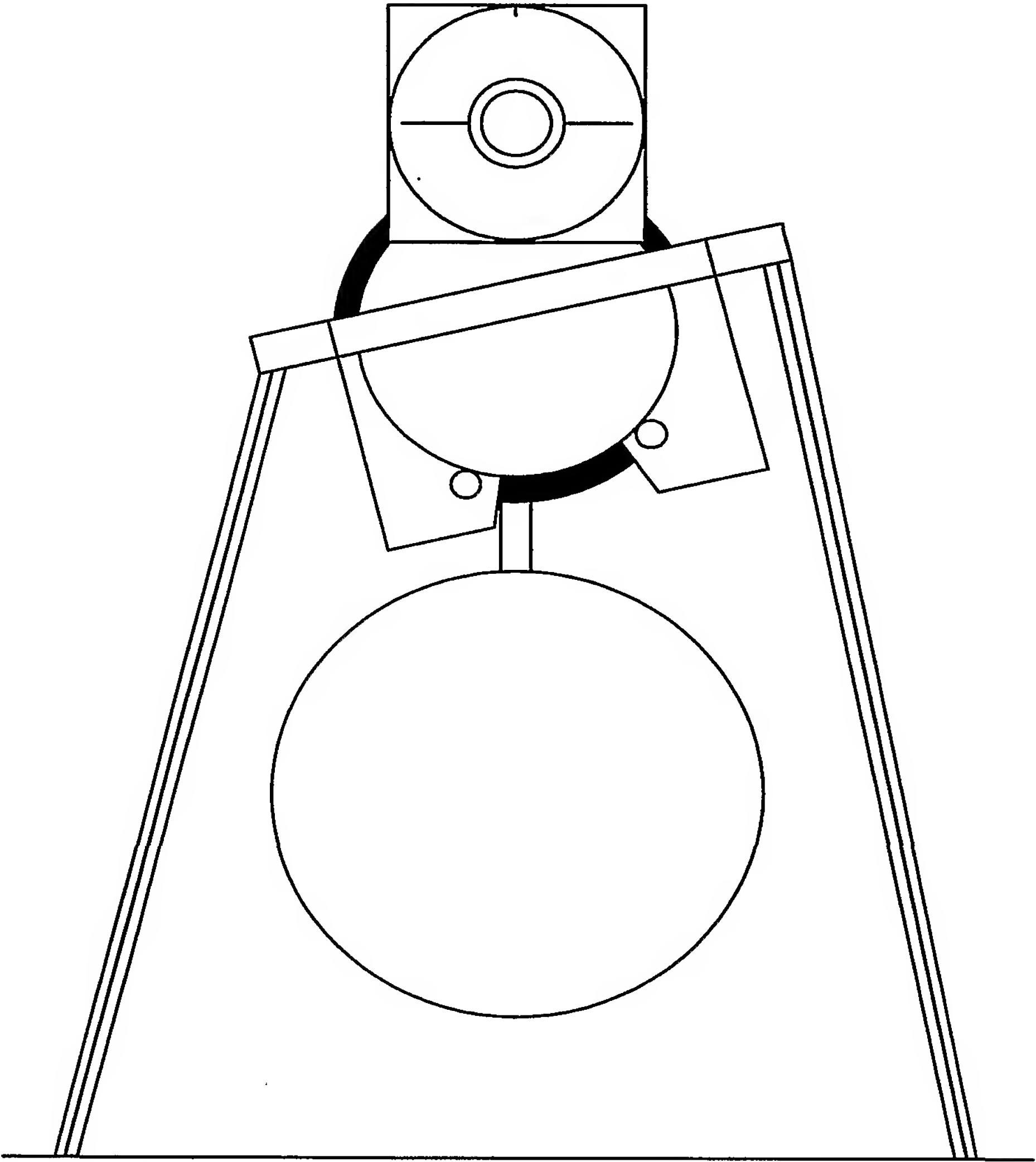
10/39  
**FIG. 12A**



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**FIG. 12B**

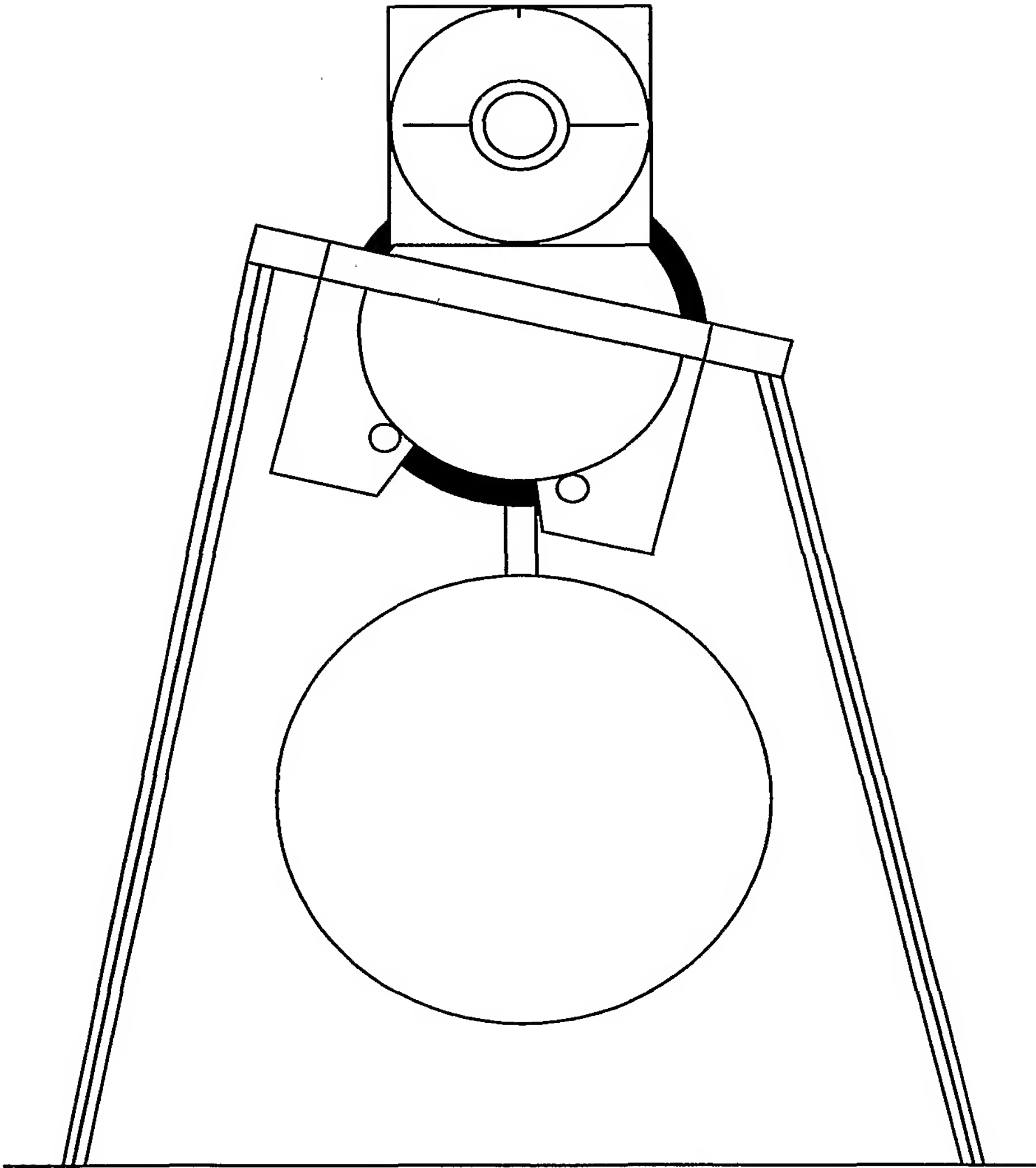


12/39  
**FIG. 12C**

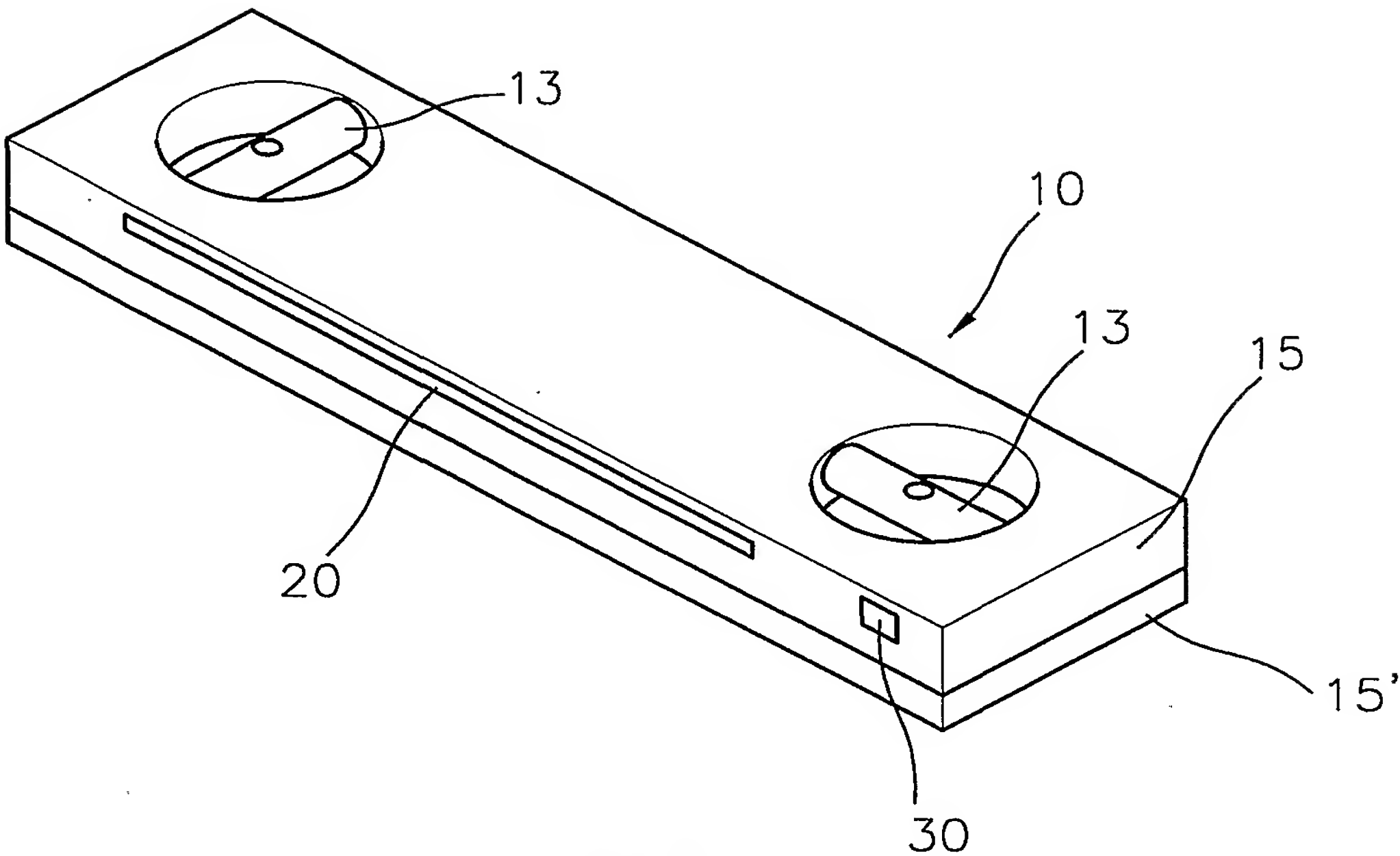




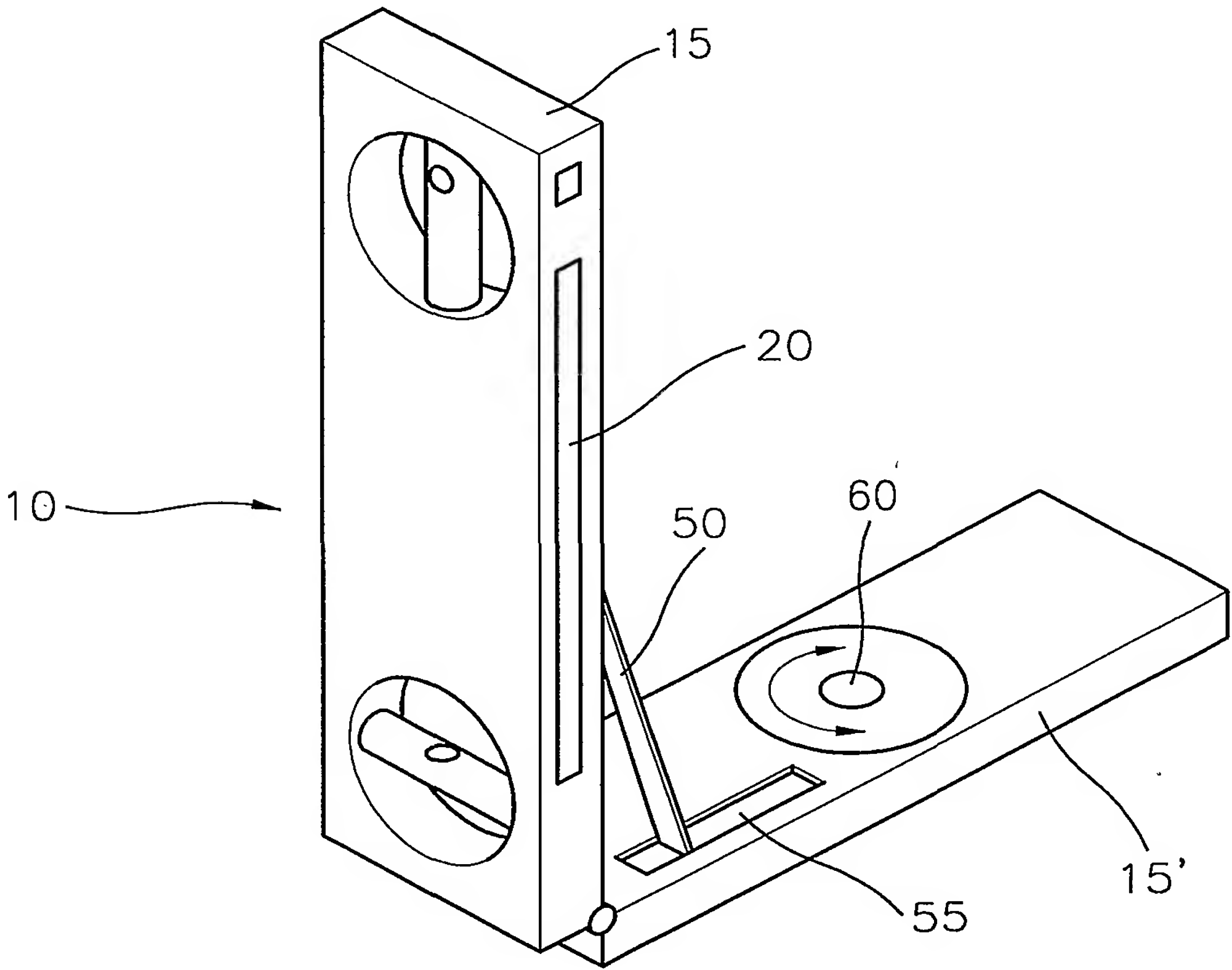
13/39  
**FIG. 12D**



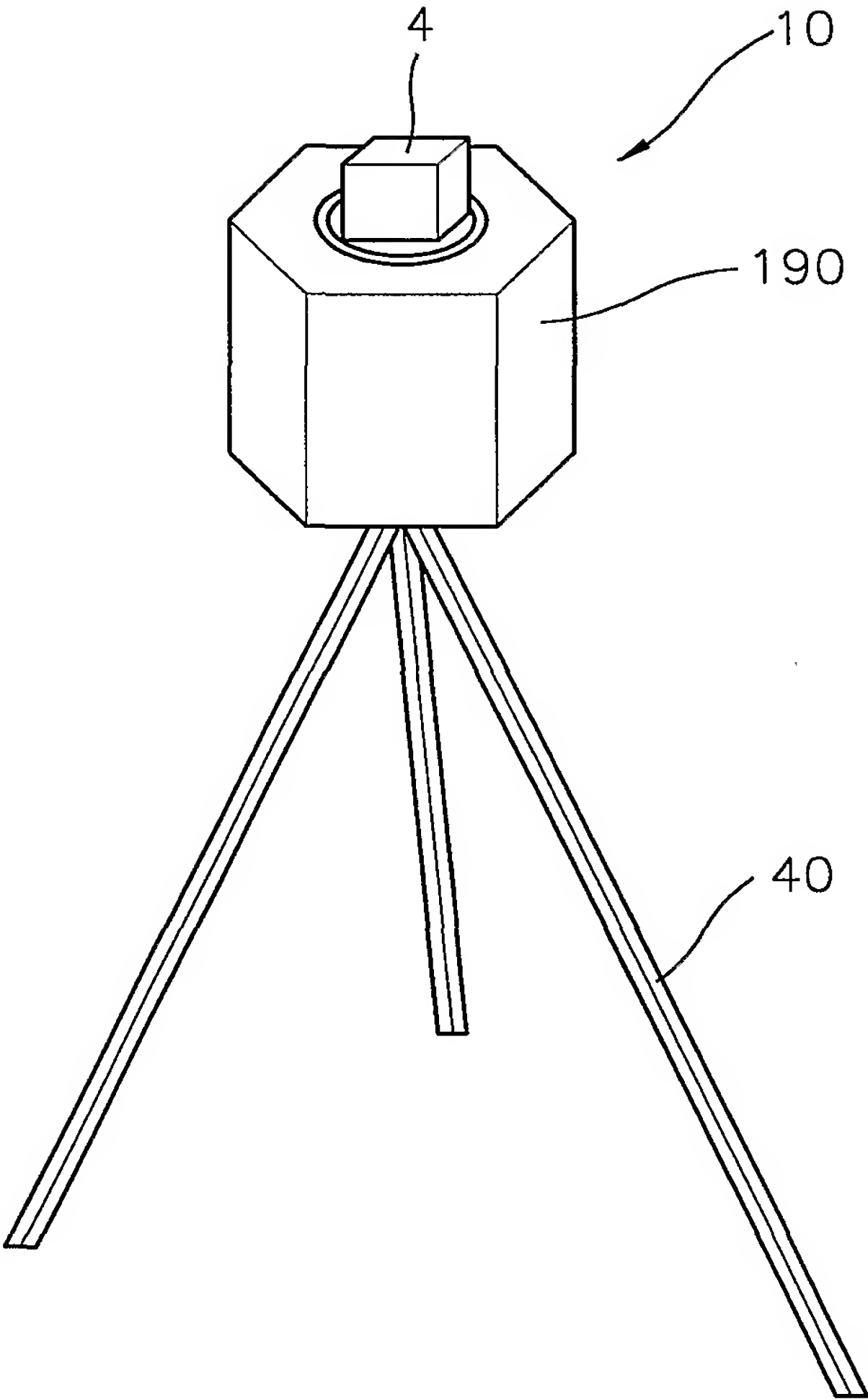
14/39  
**FIG. 13**



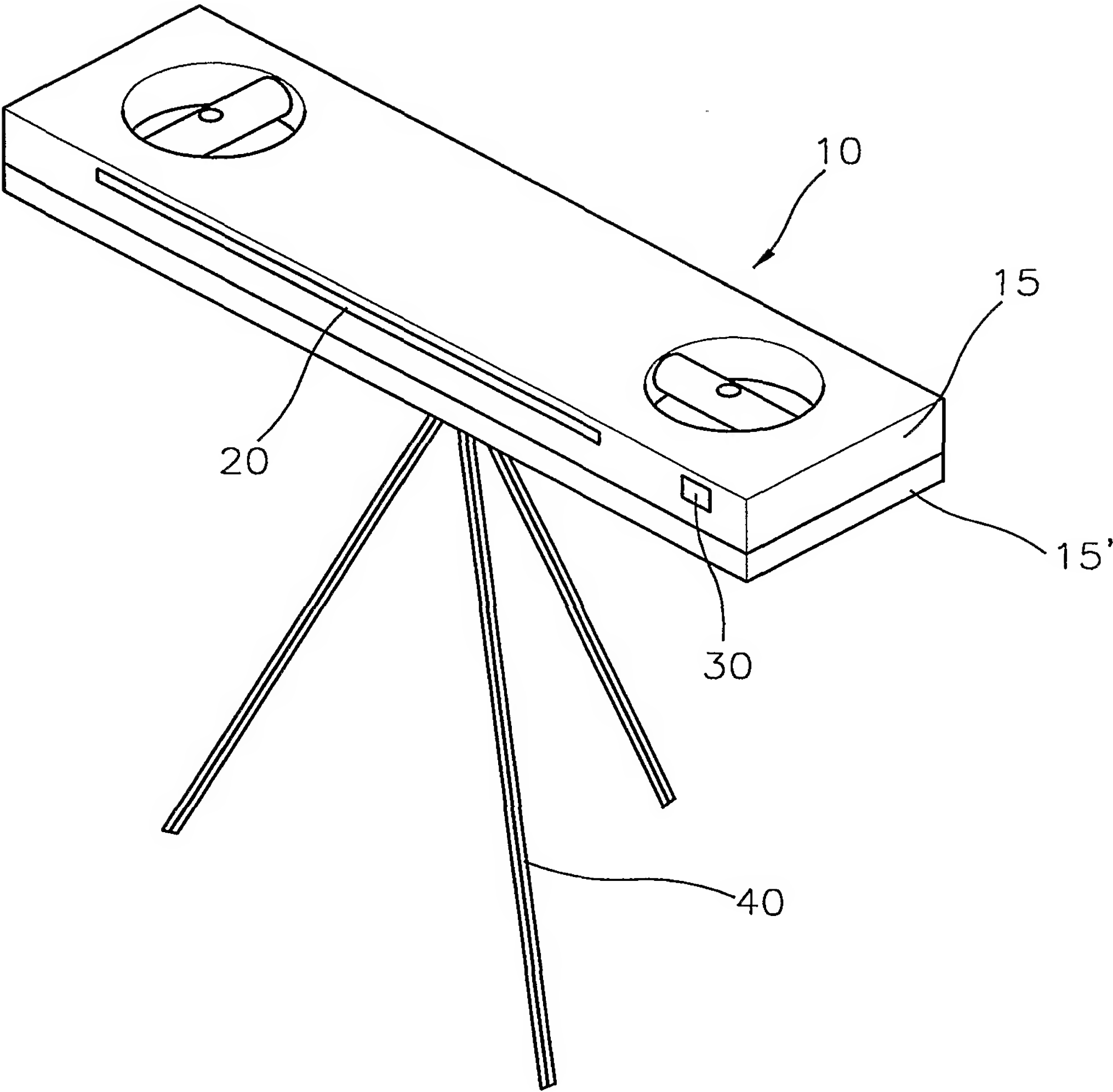
**FIG. 14**



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**FIG. 15**

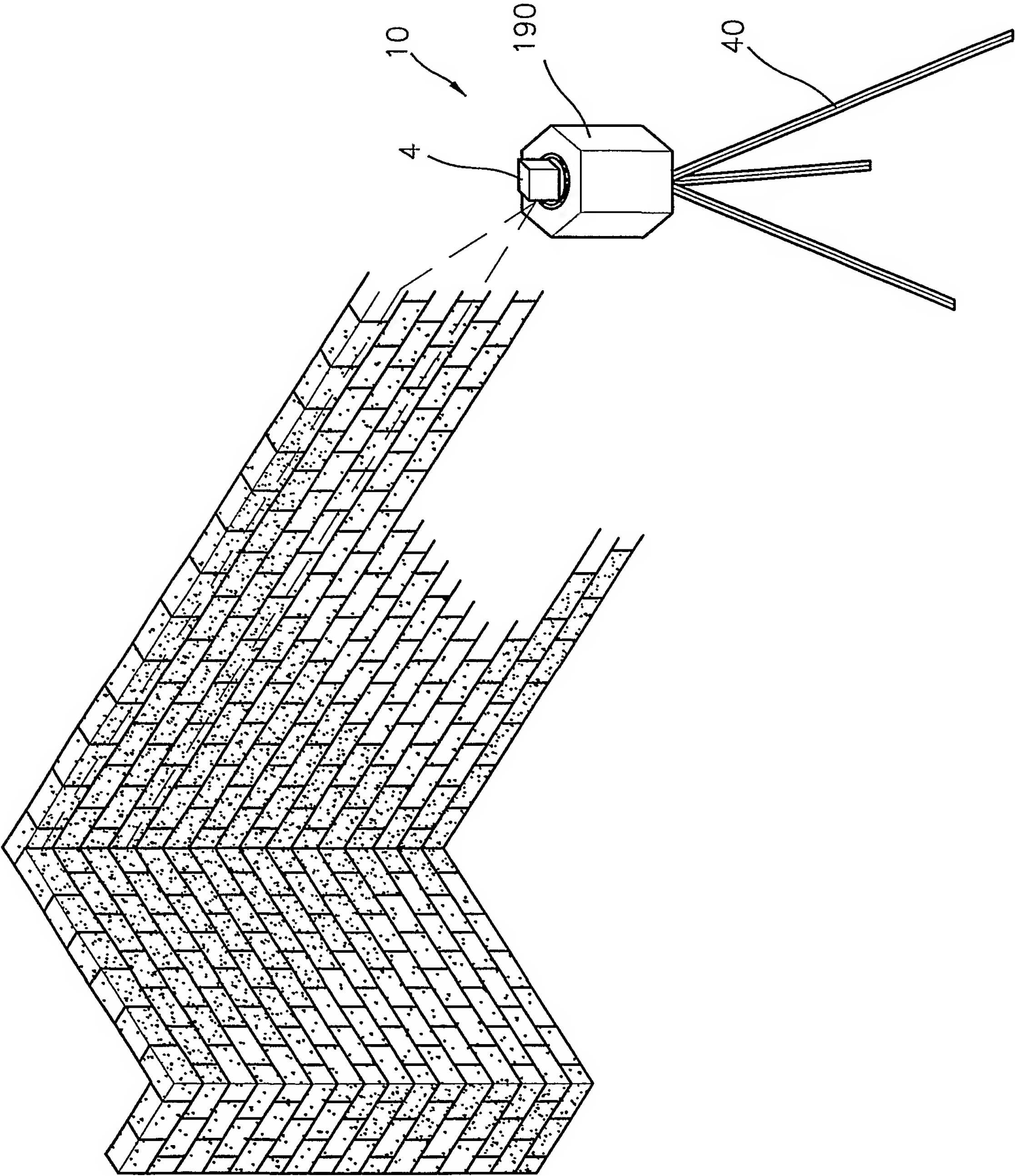


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**FIG. 16**



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FIG. 17



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FIG. 18

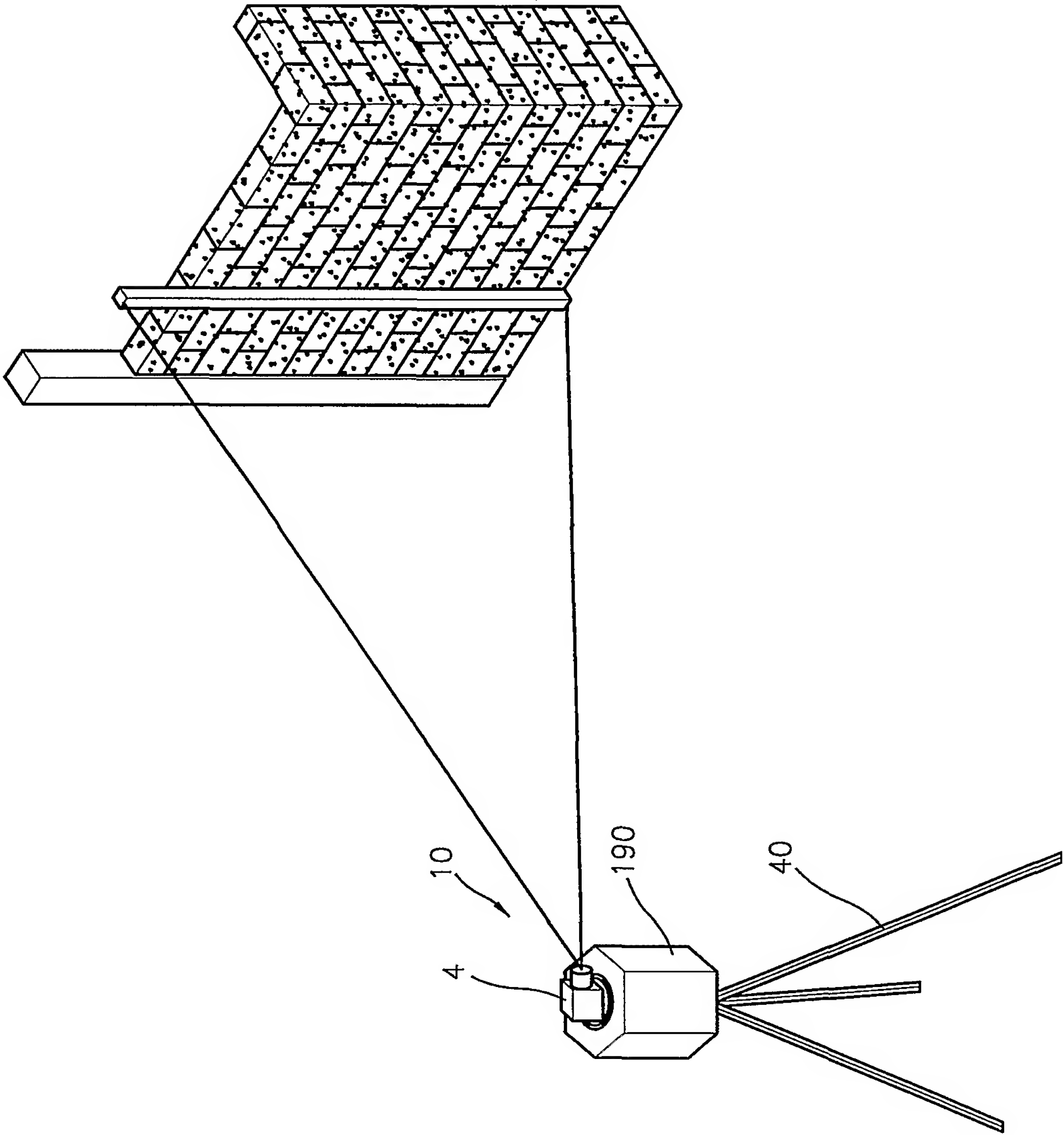
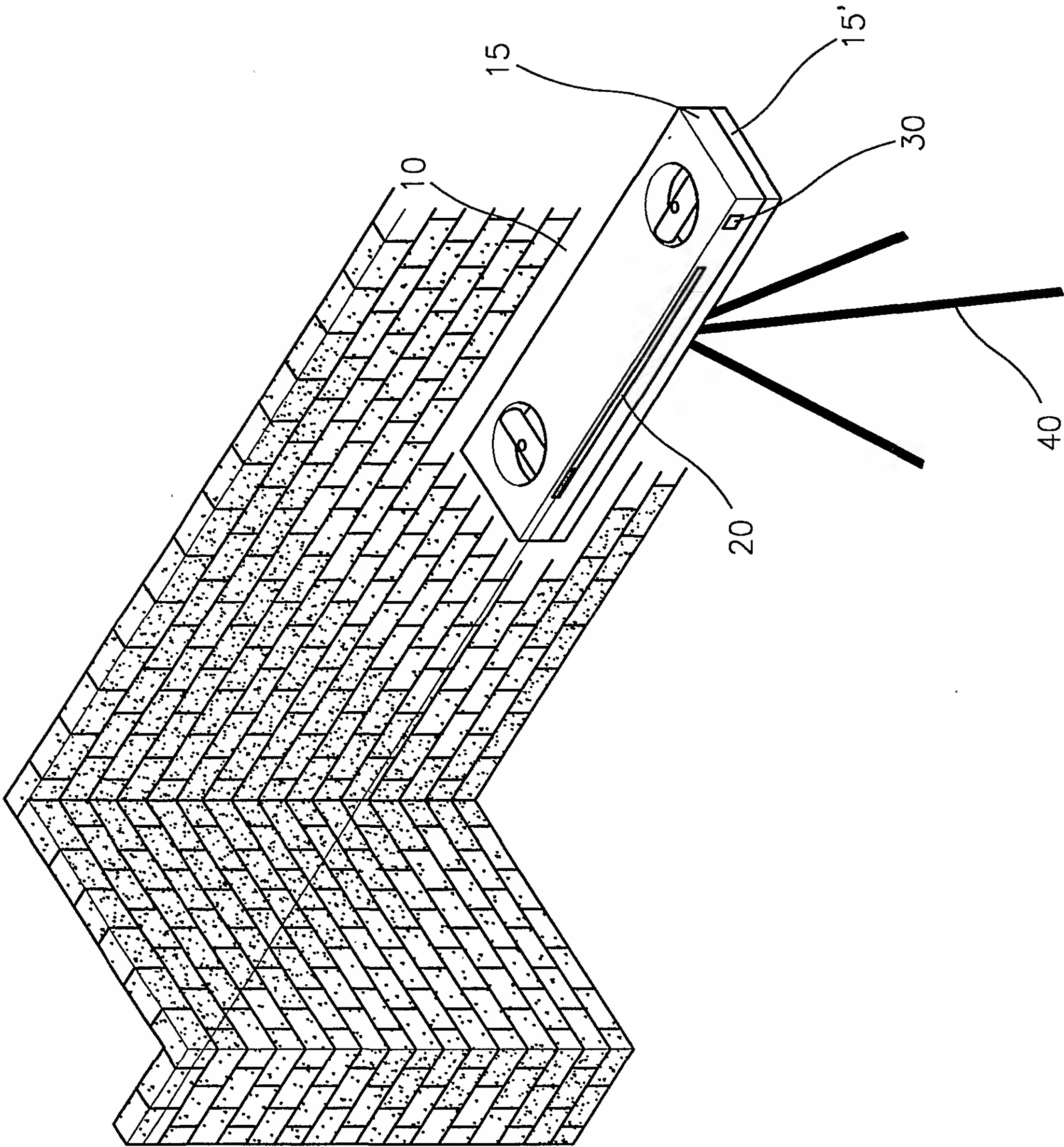




FIG. 19



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FIG. 20

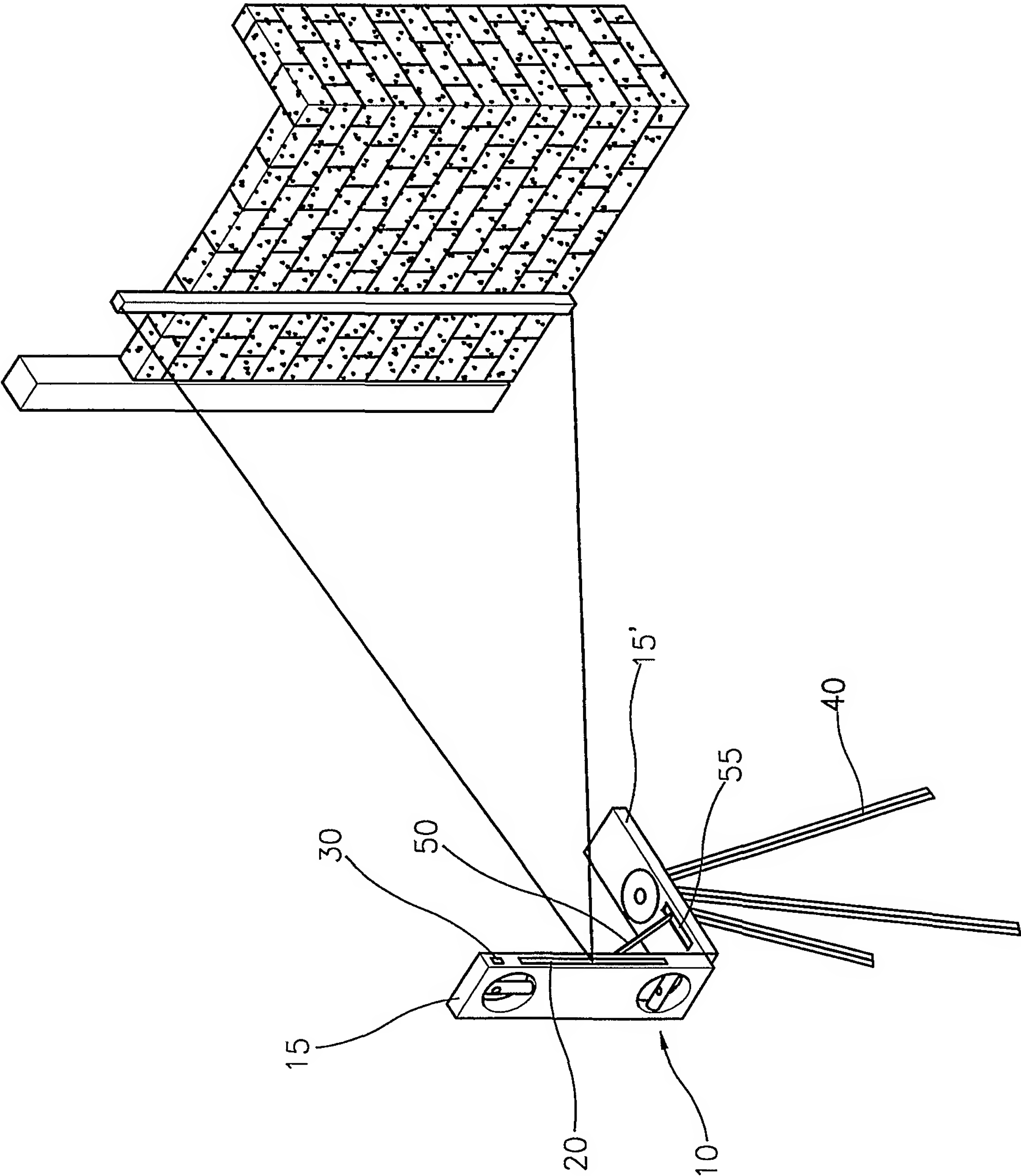


FIG. 21A

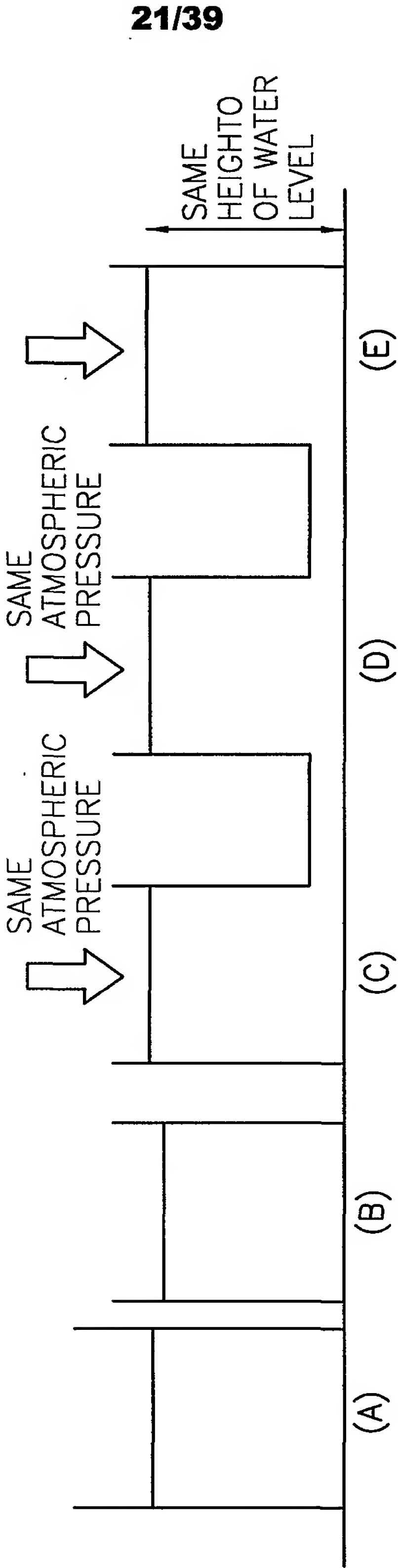
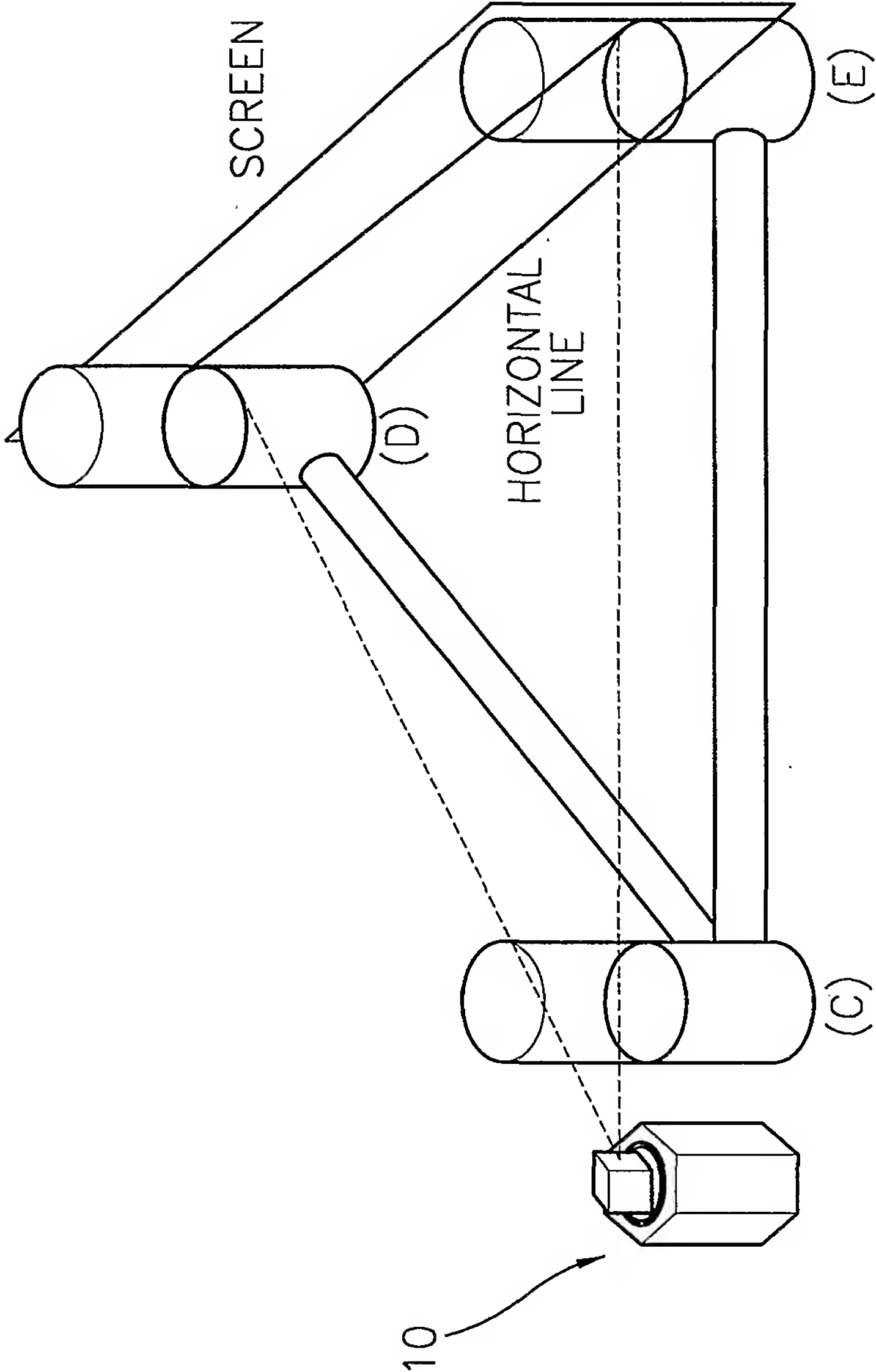
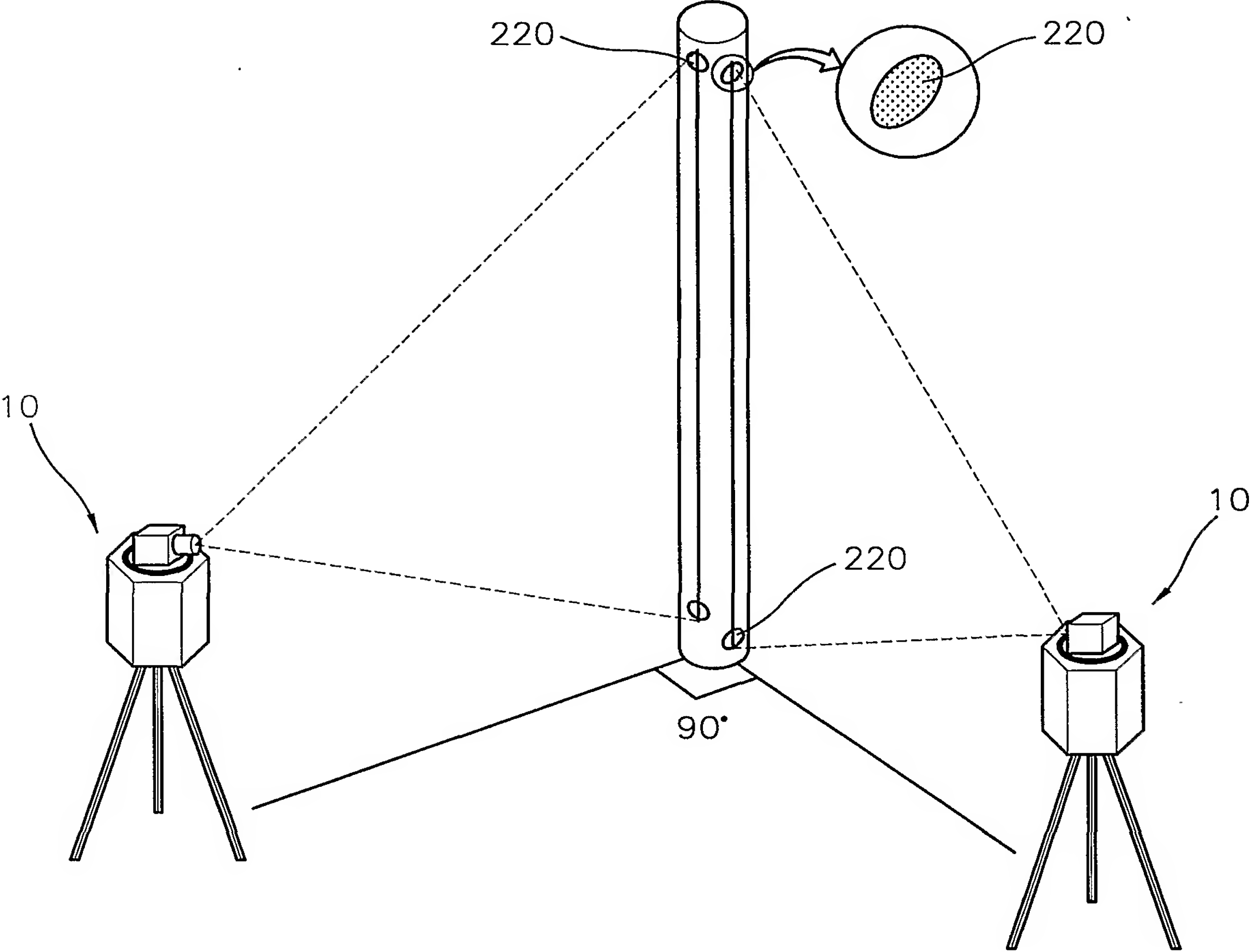


FIG. 21B



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**FIG. 22A**



**FIG. 22B**

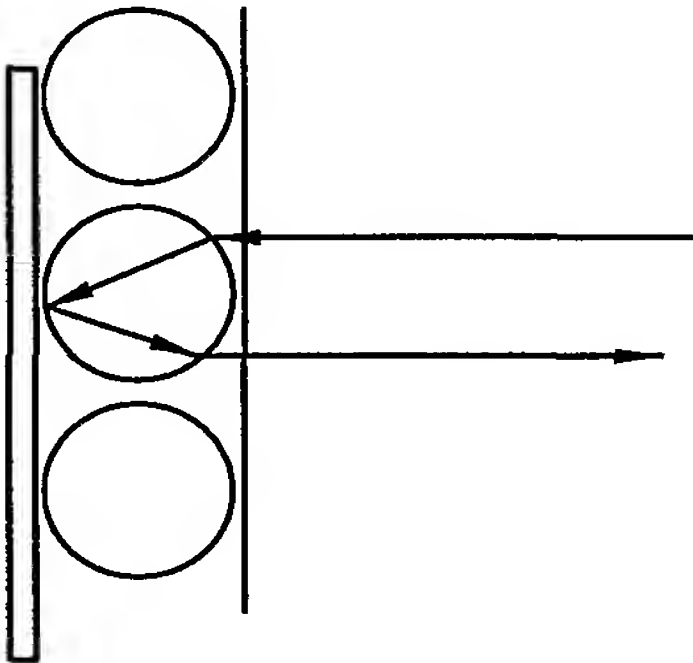


FIG. 23

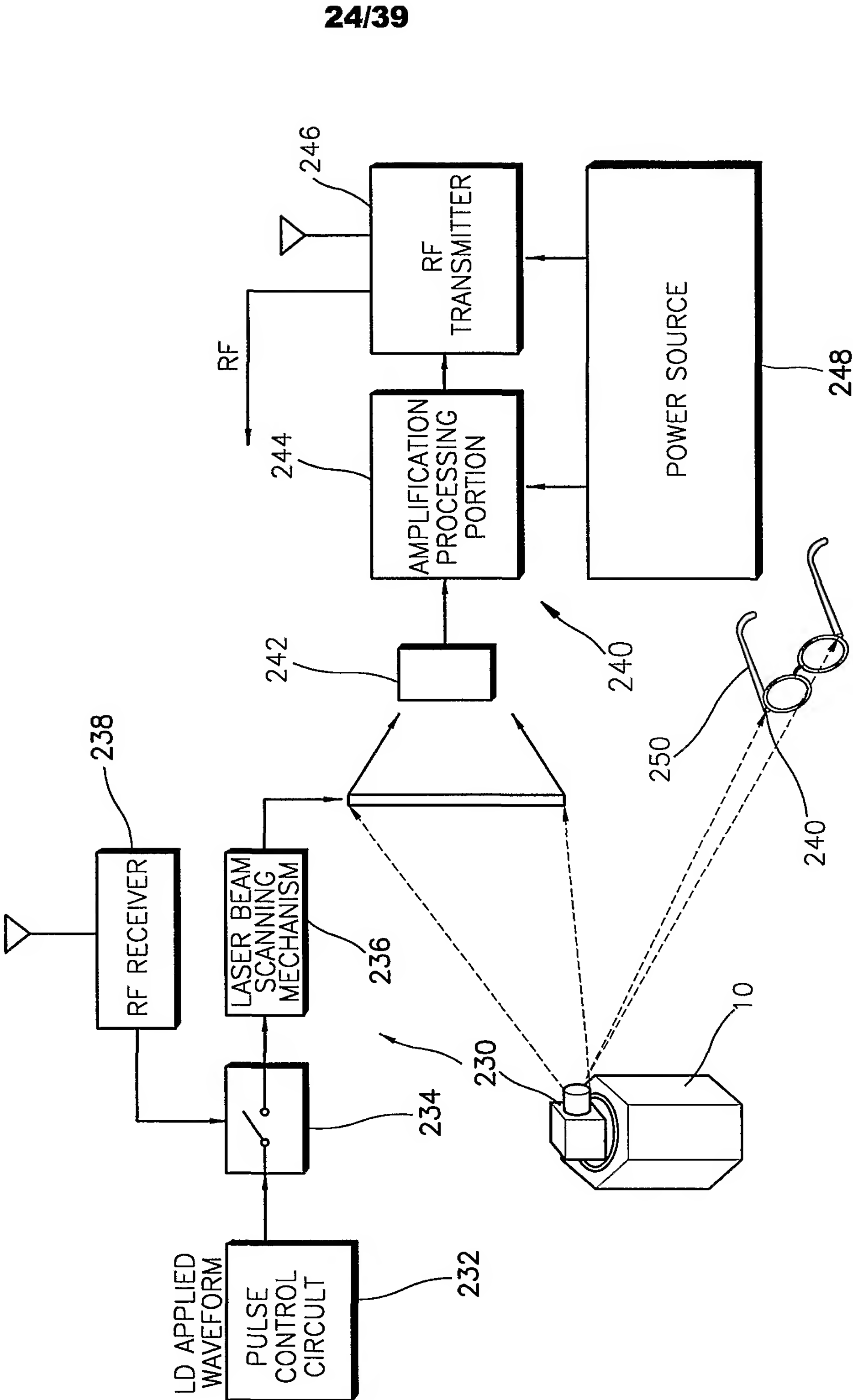
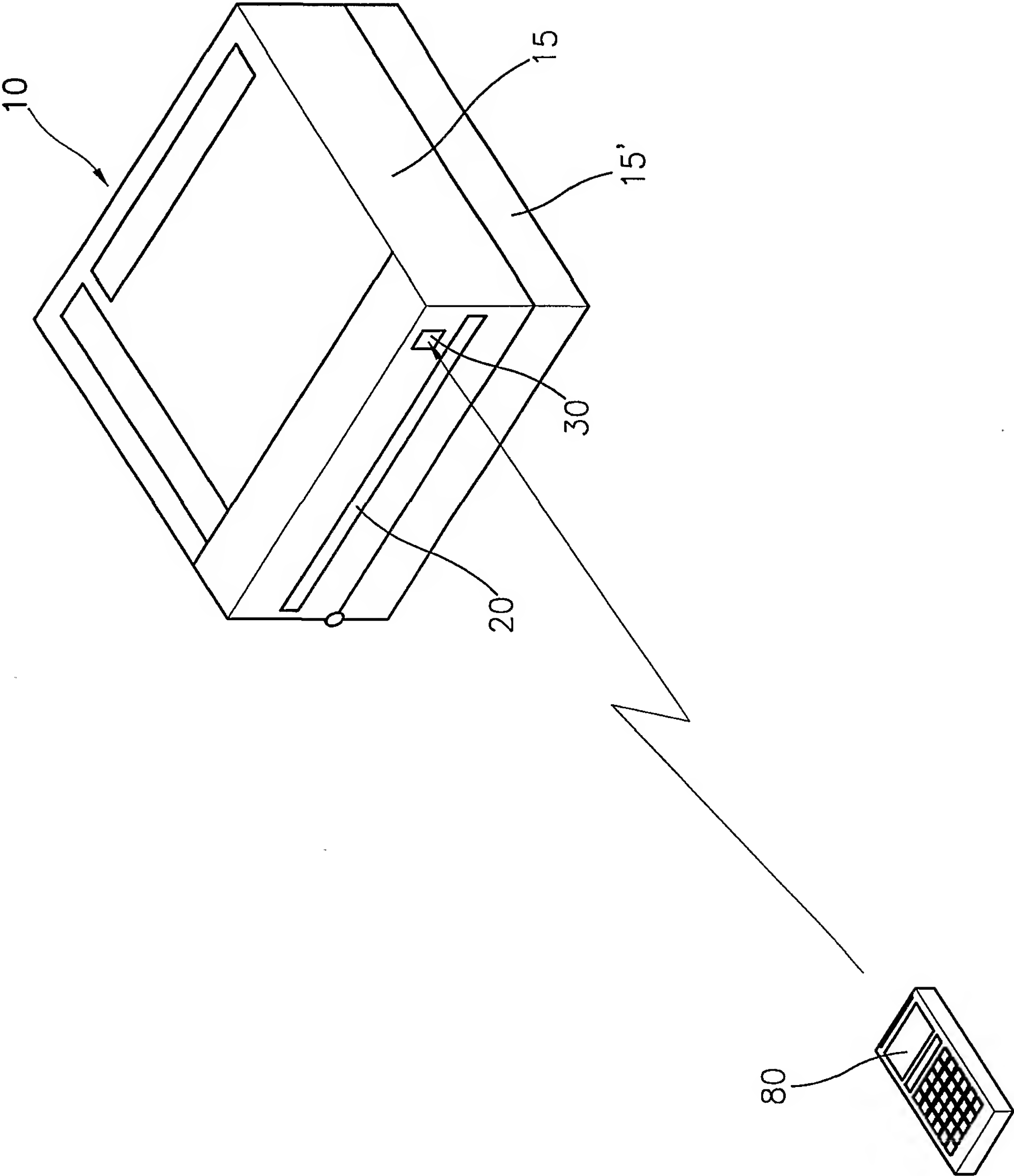
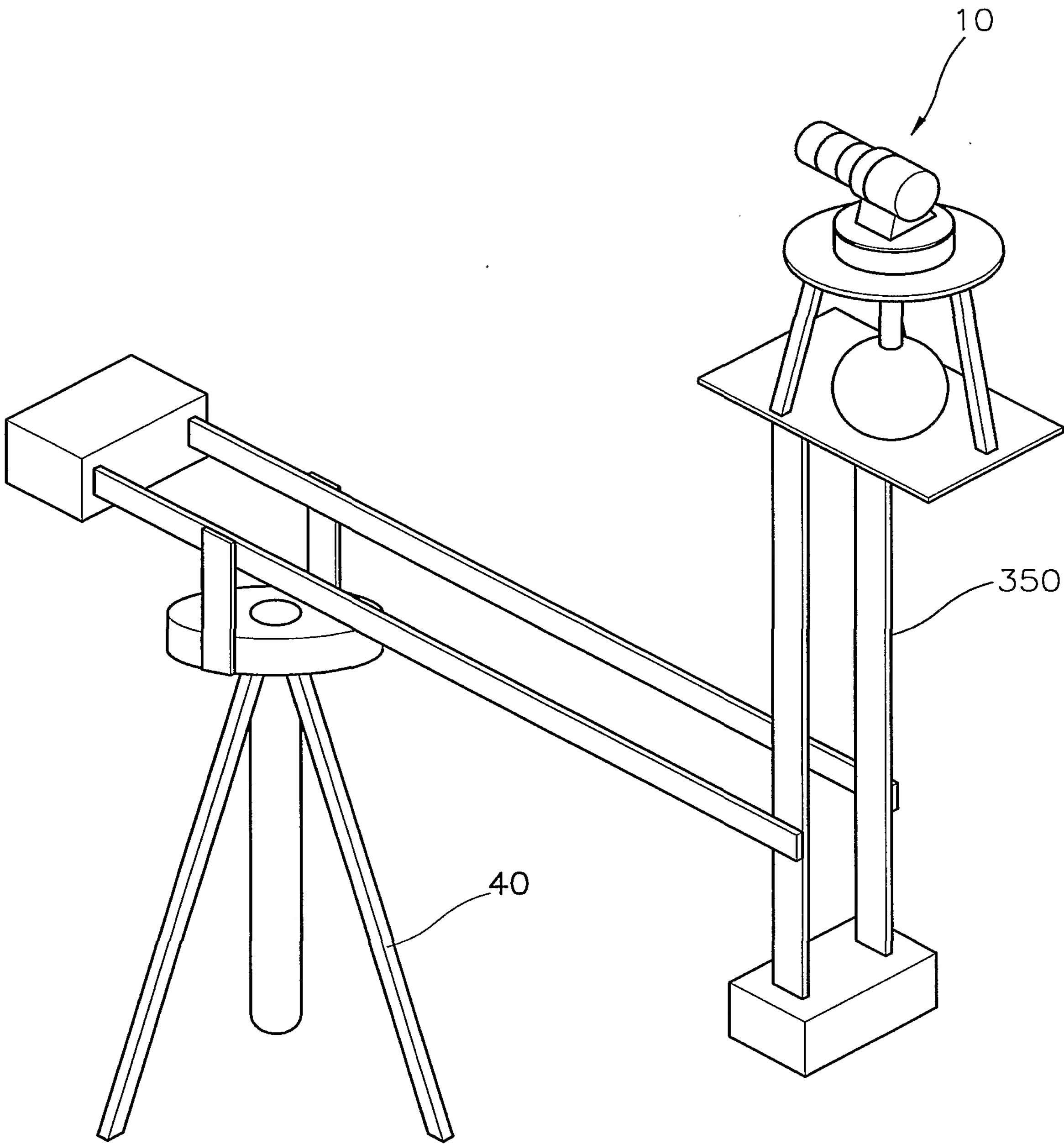




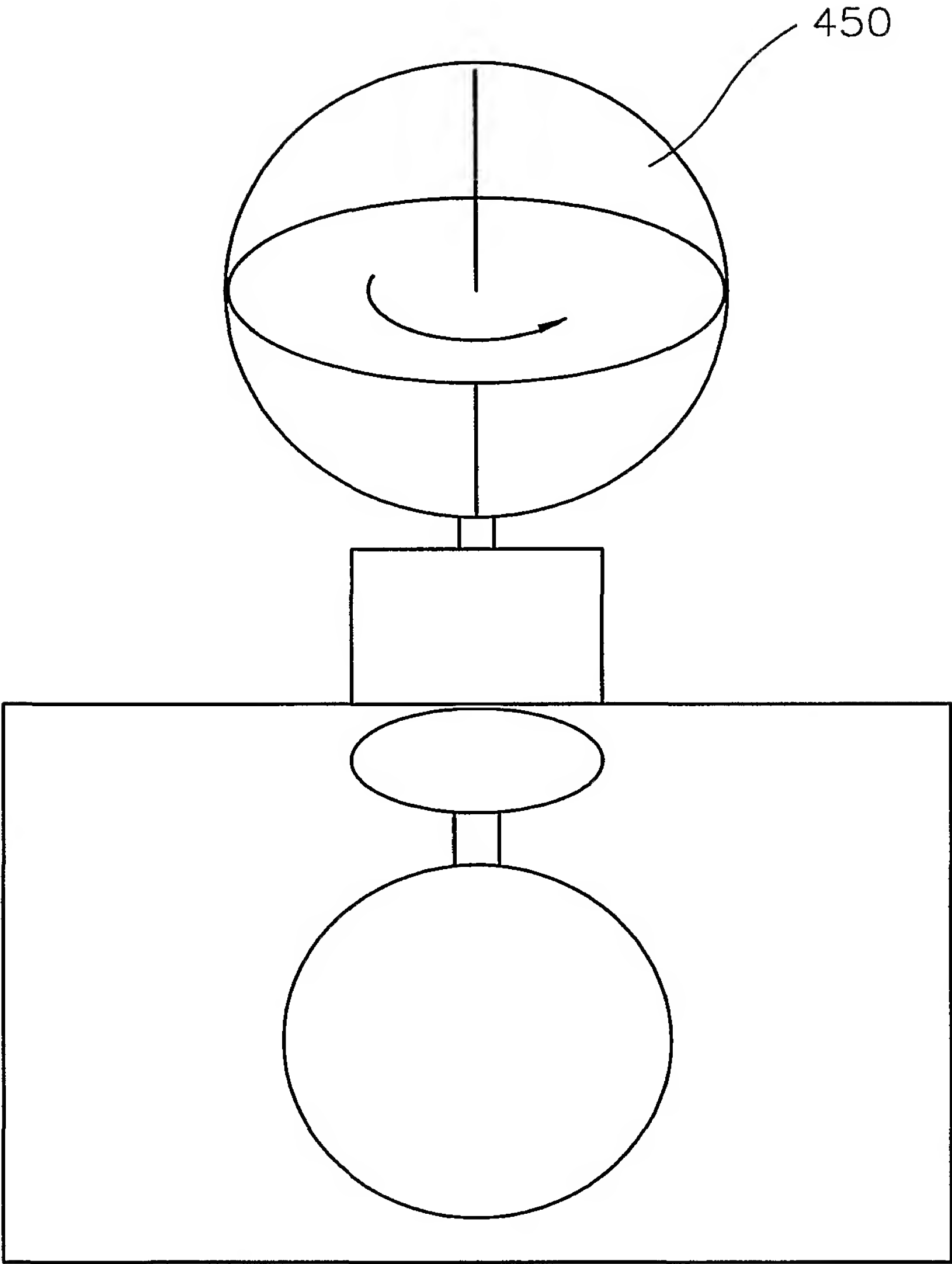
FIG. 24



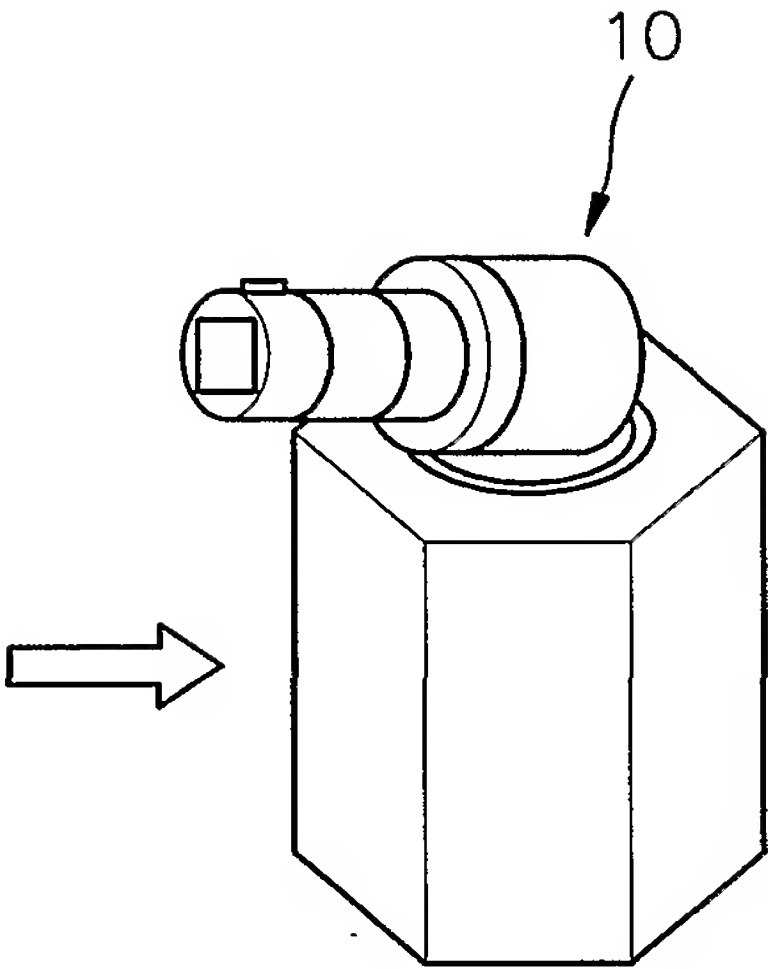
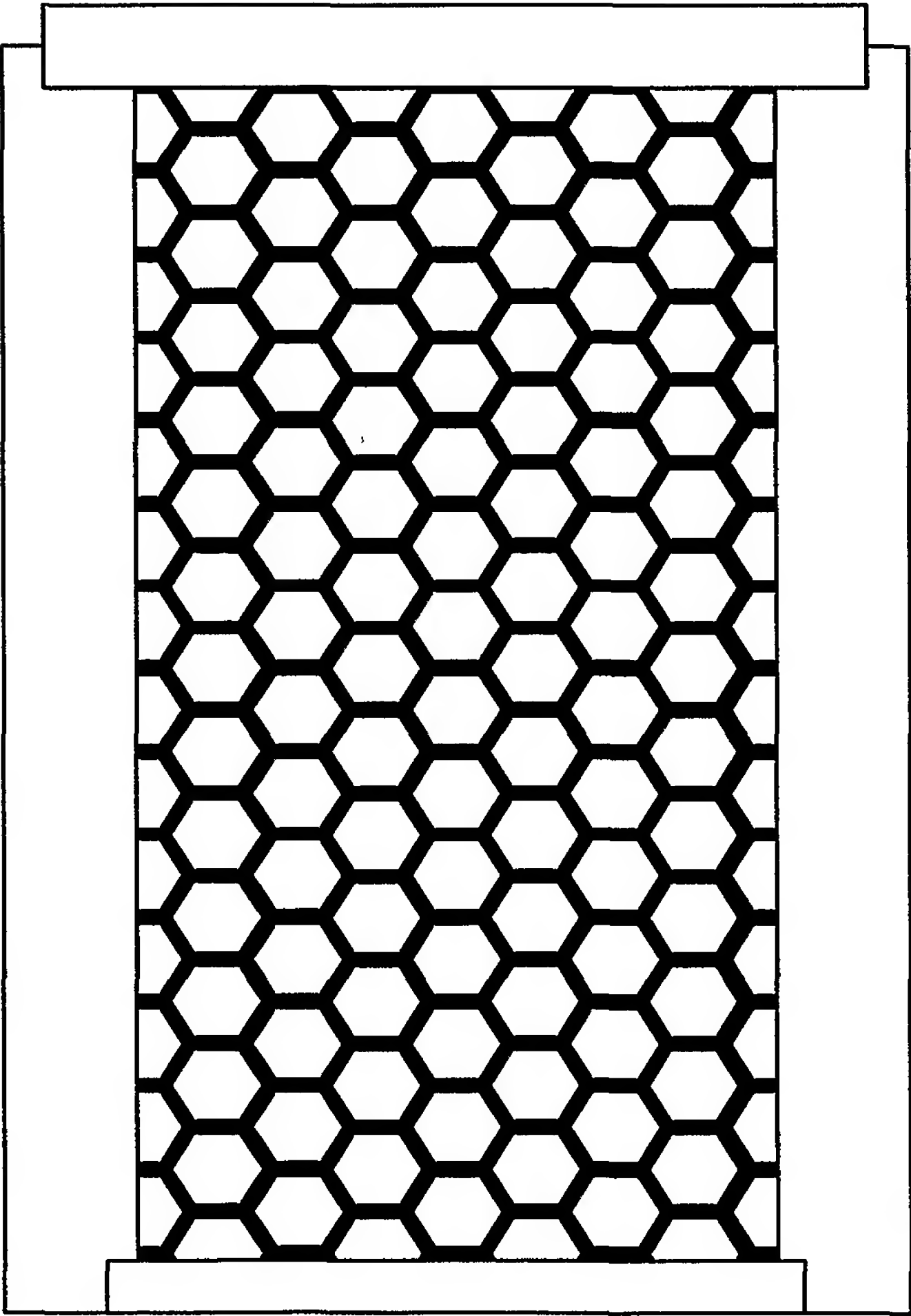
26/39  
**FIG. 25**



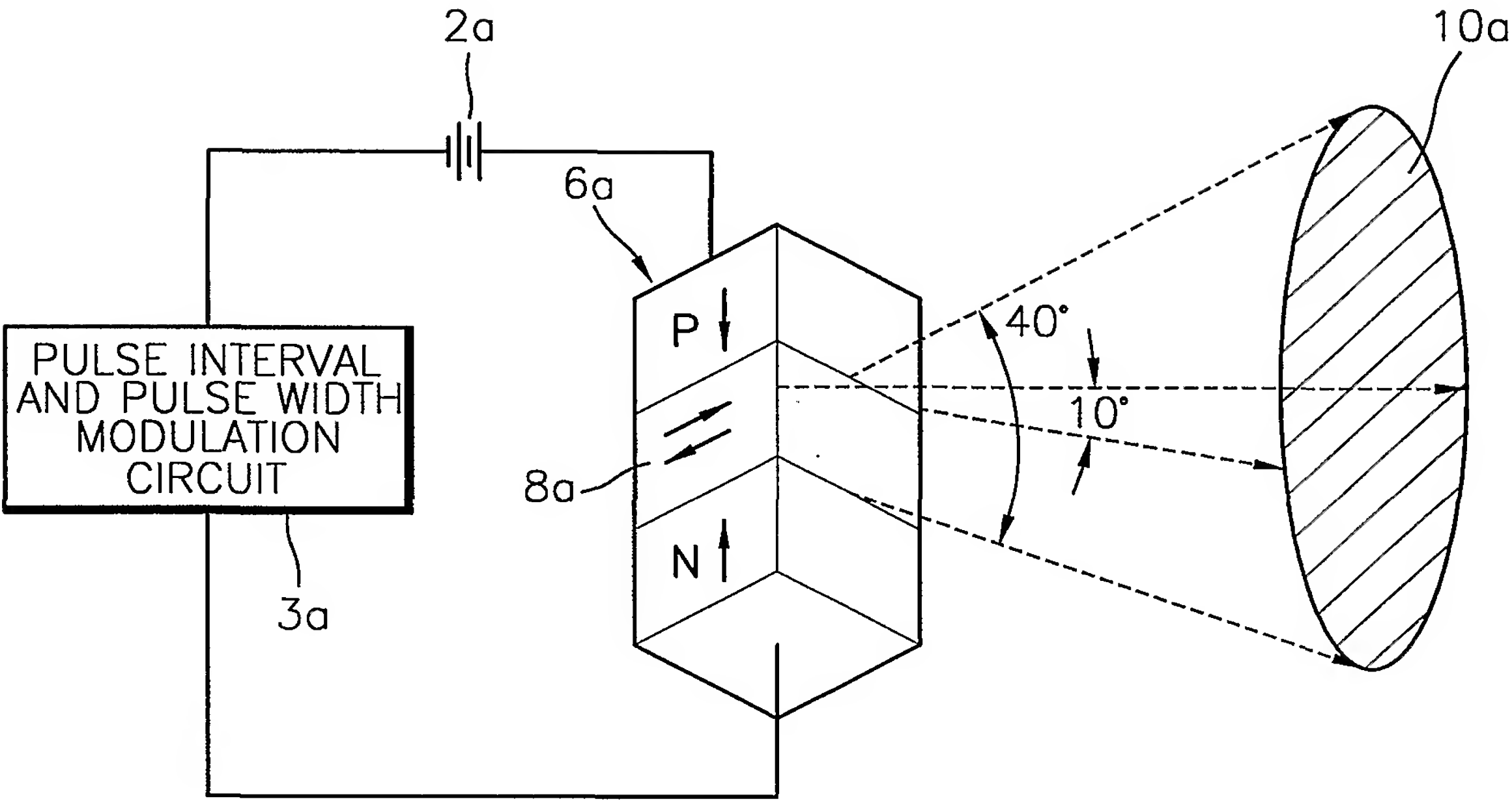
27/39  
**FIG. 26**



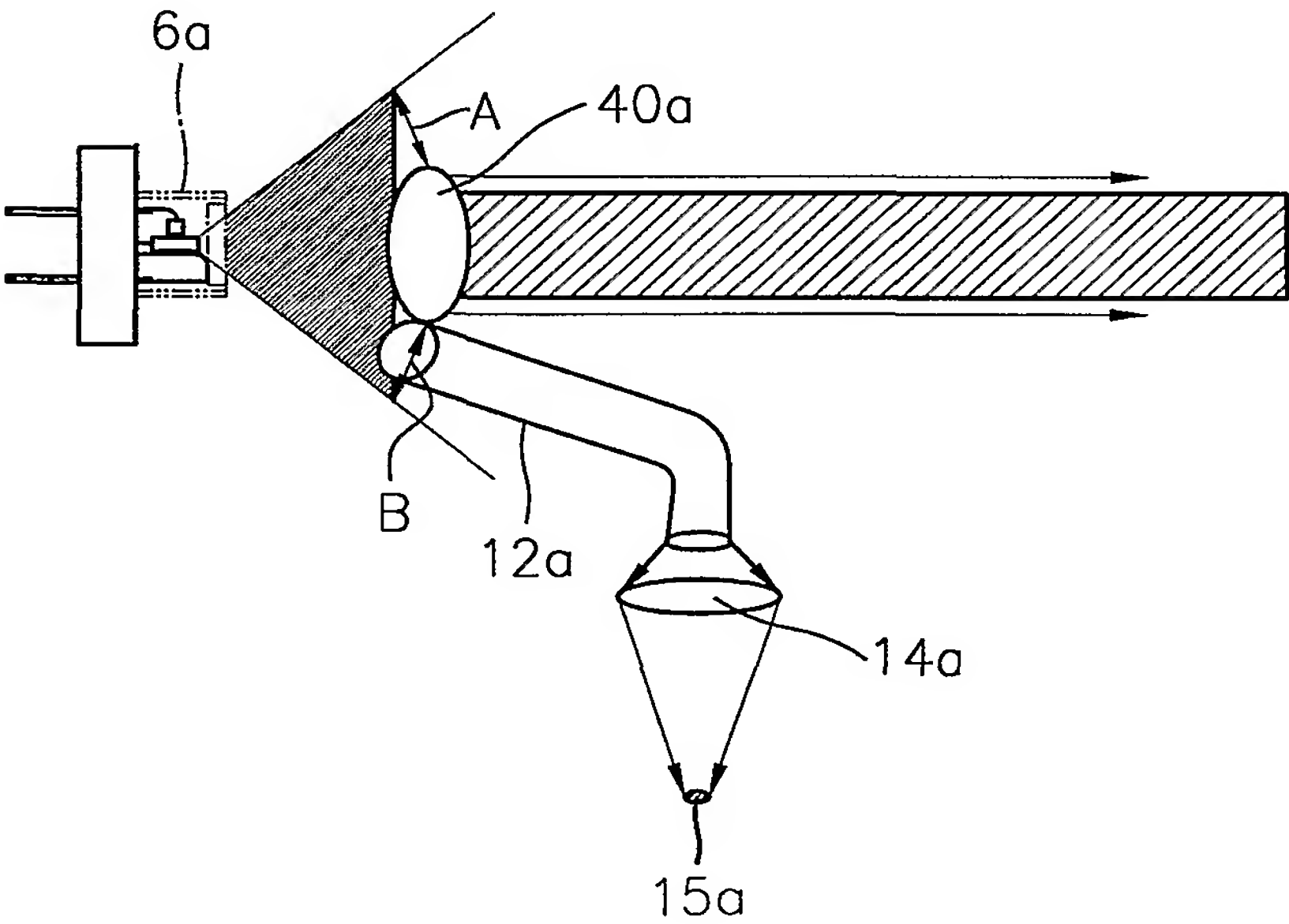
28/39  
**FIG. 27**



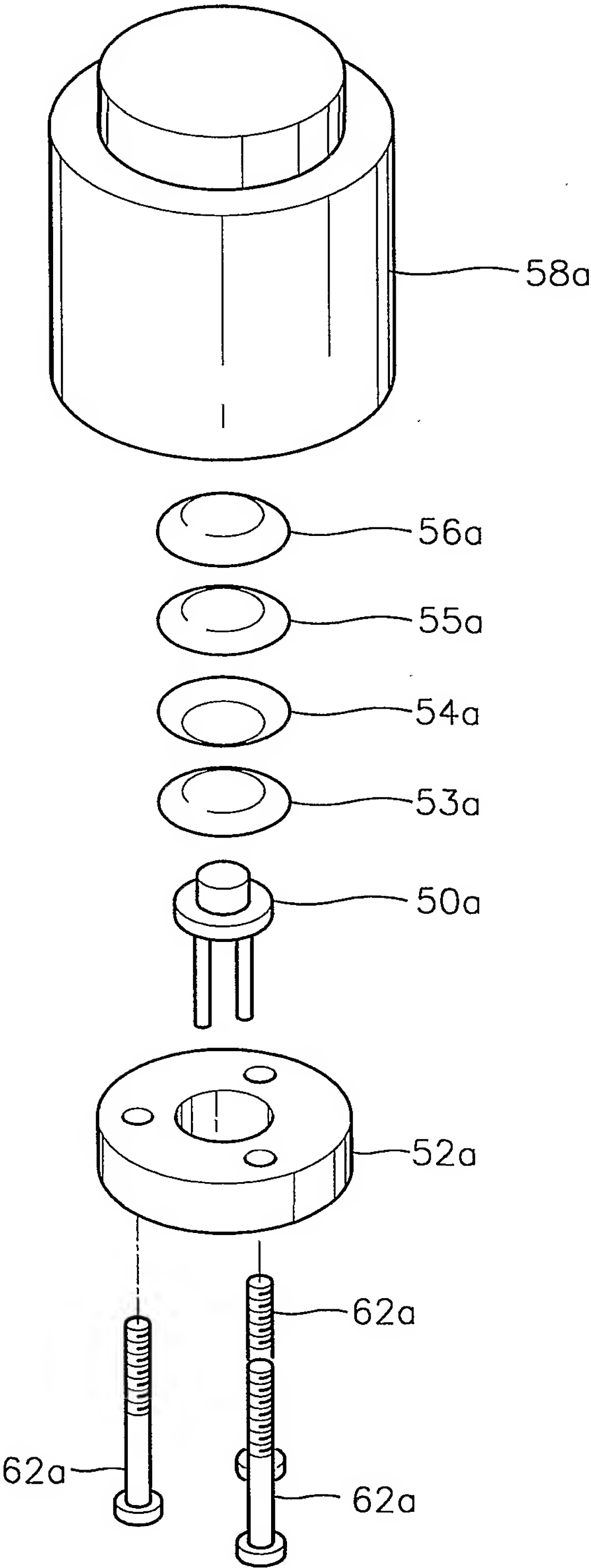
29/39  
**FIG. 28**



**FIG. 29**

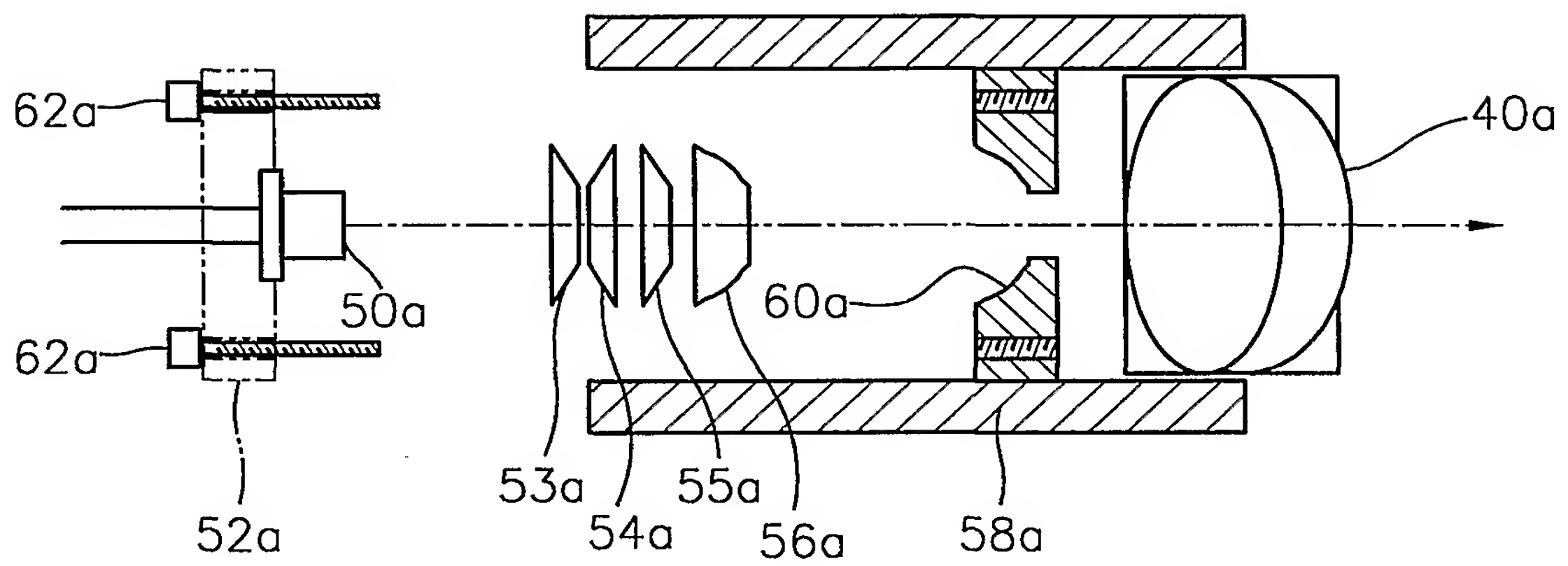


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**FIG. 30**

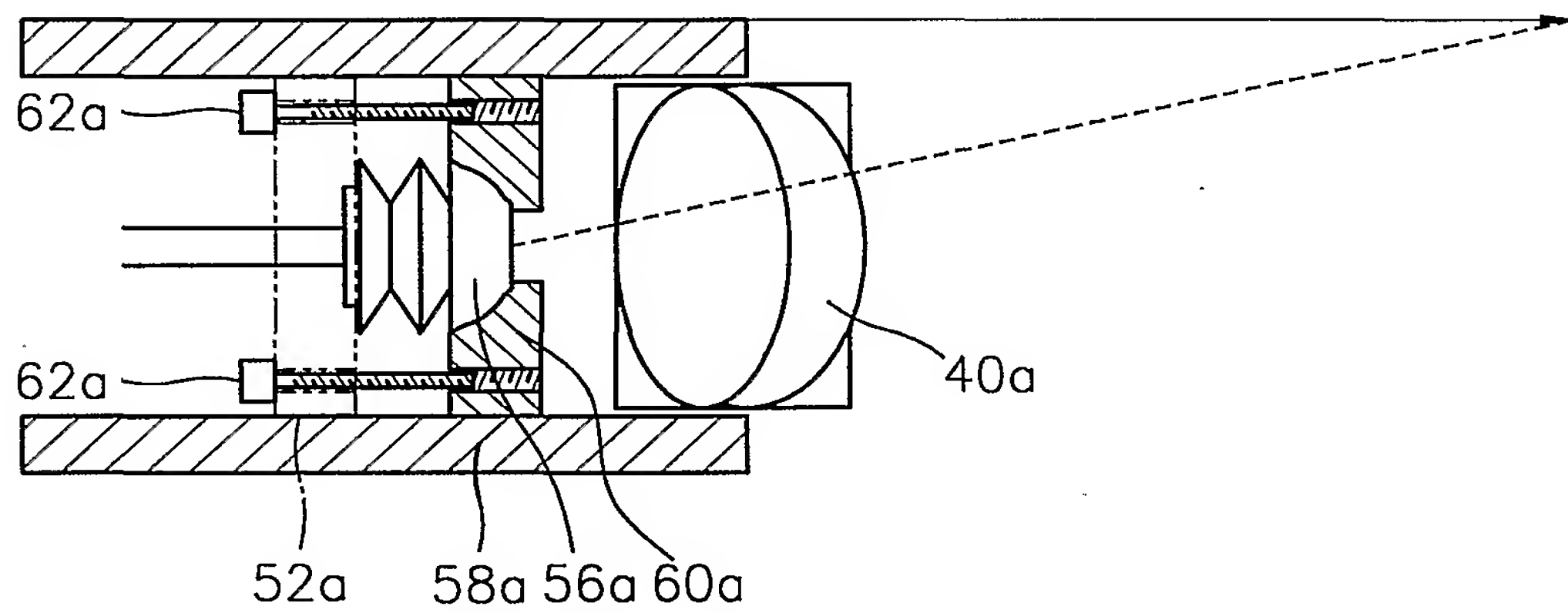




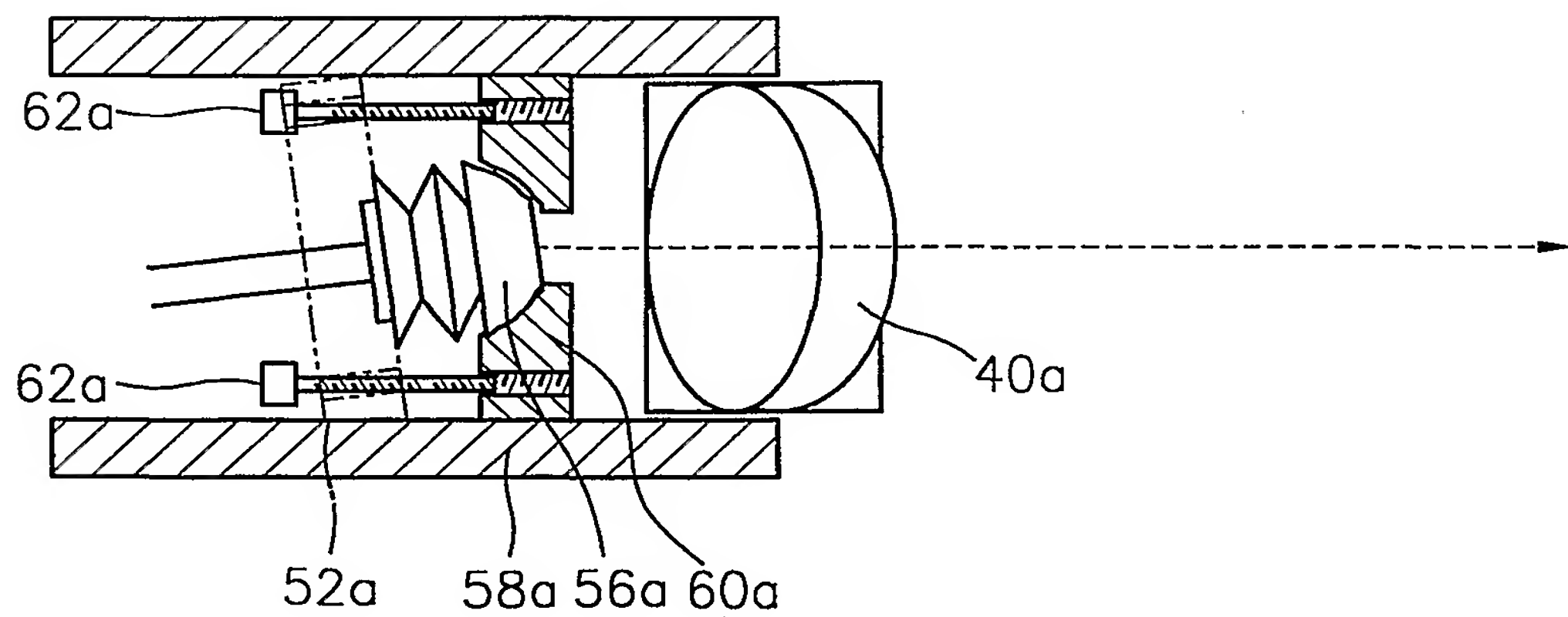
31/39  
**FIG. 31**



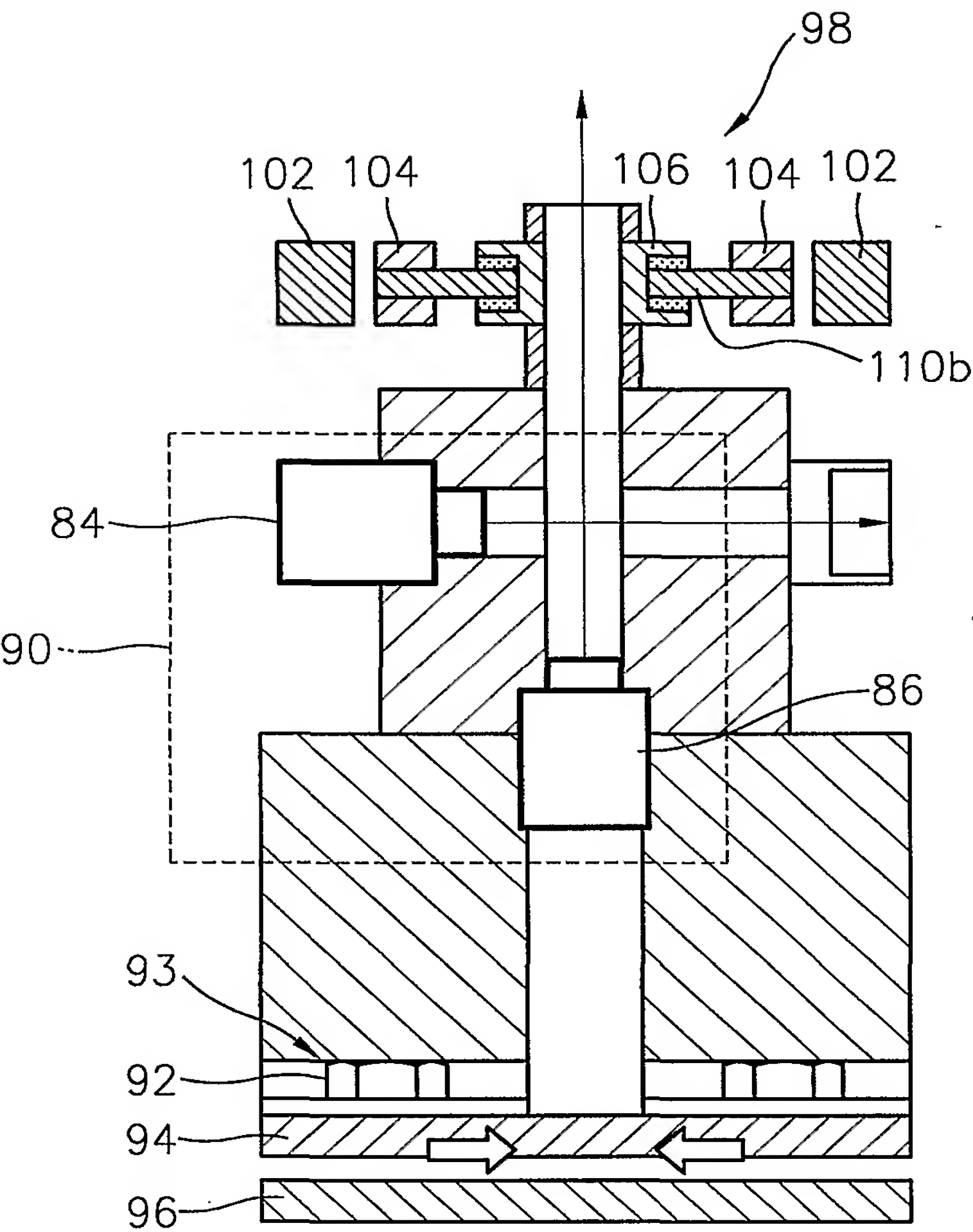
**FIG. 32**



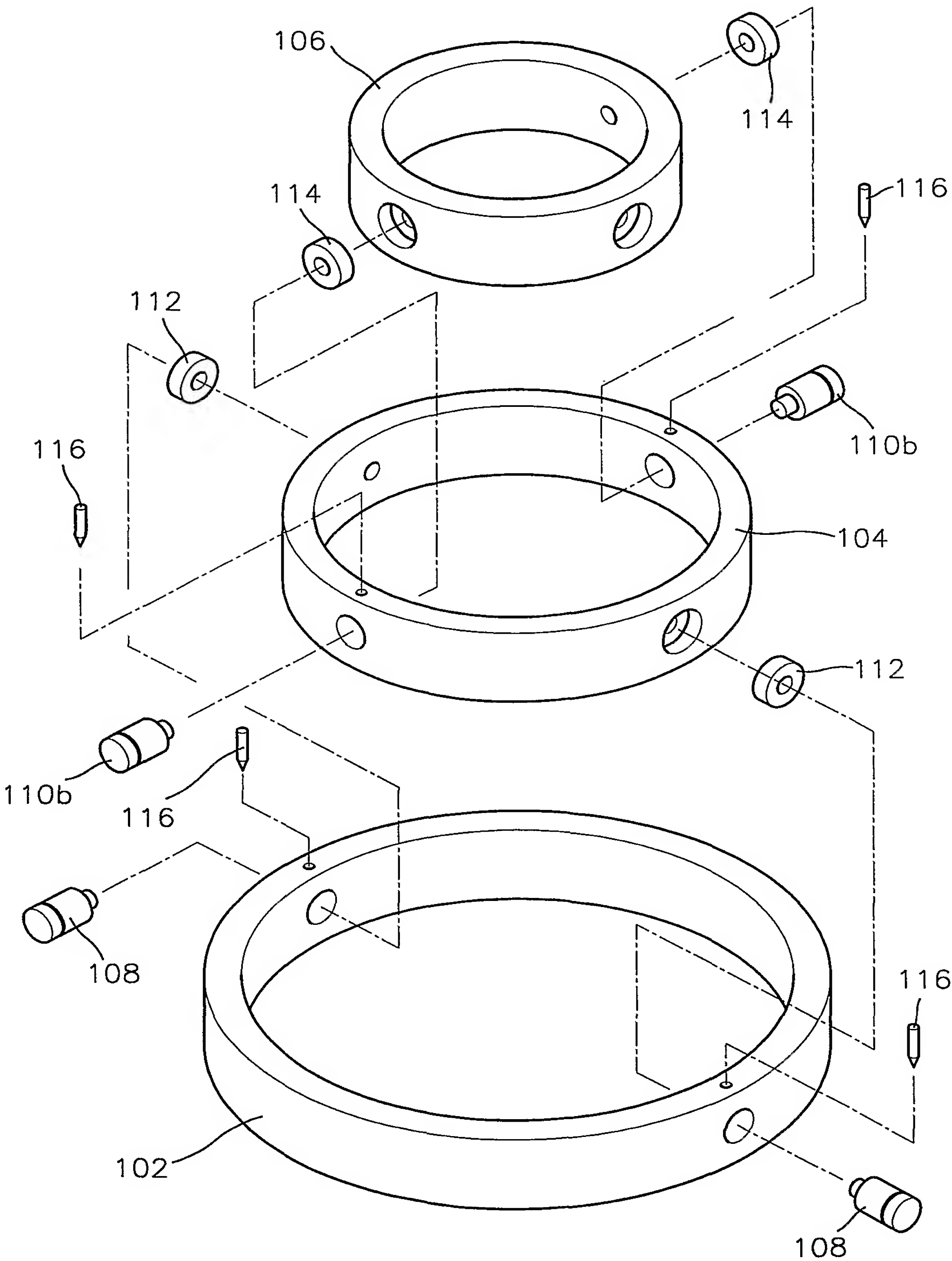
**FIG. 33**



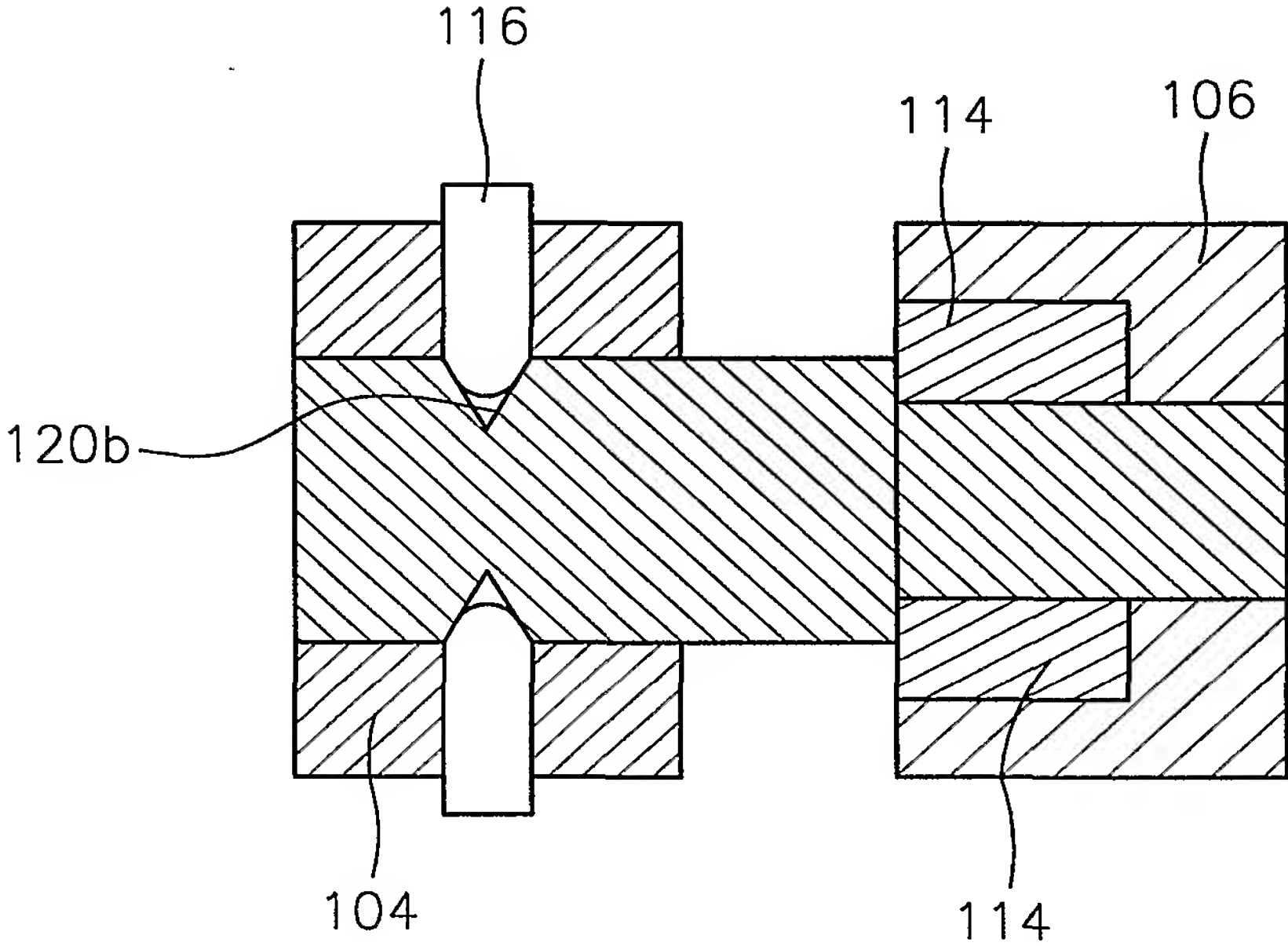
32/39  
**FIG. 34**



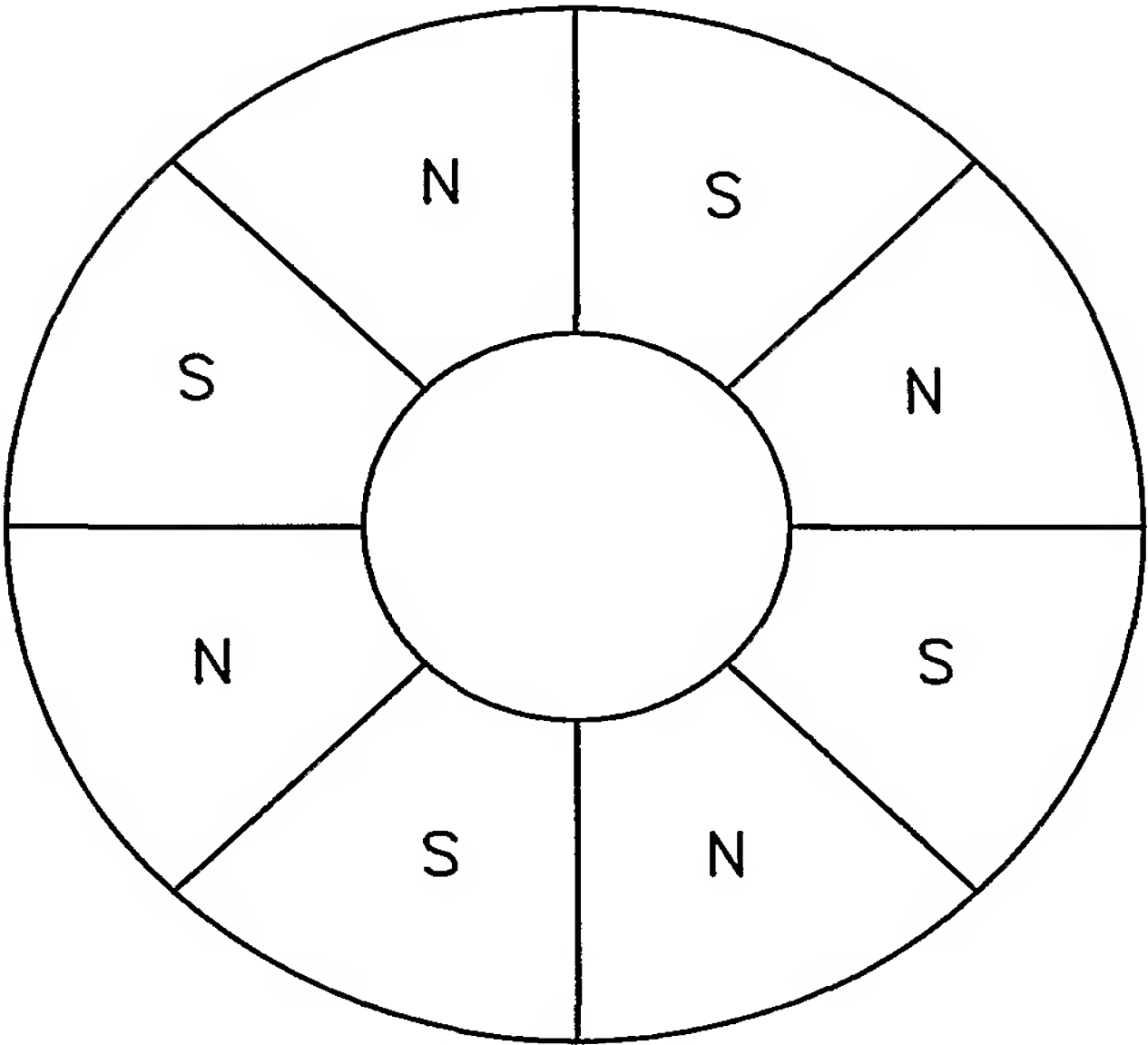
33/39  
**FIG. 35**



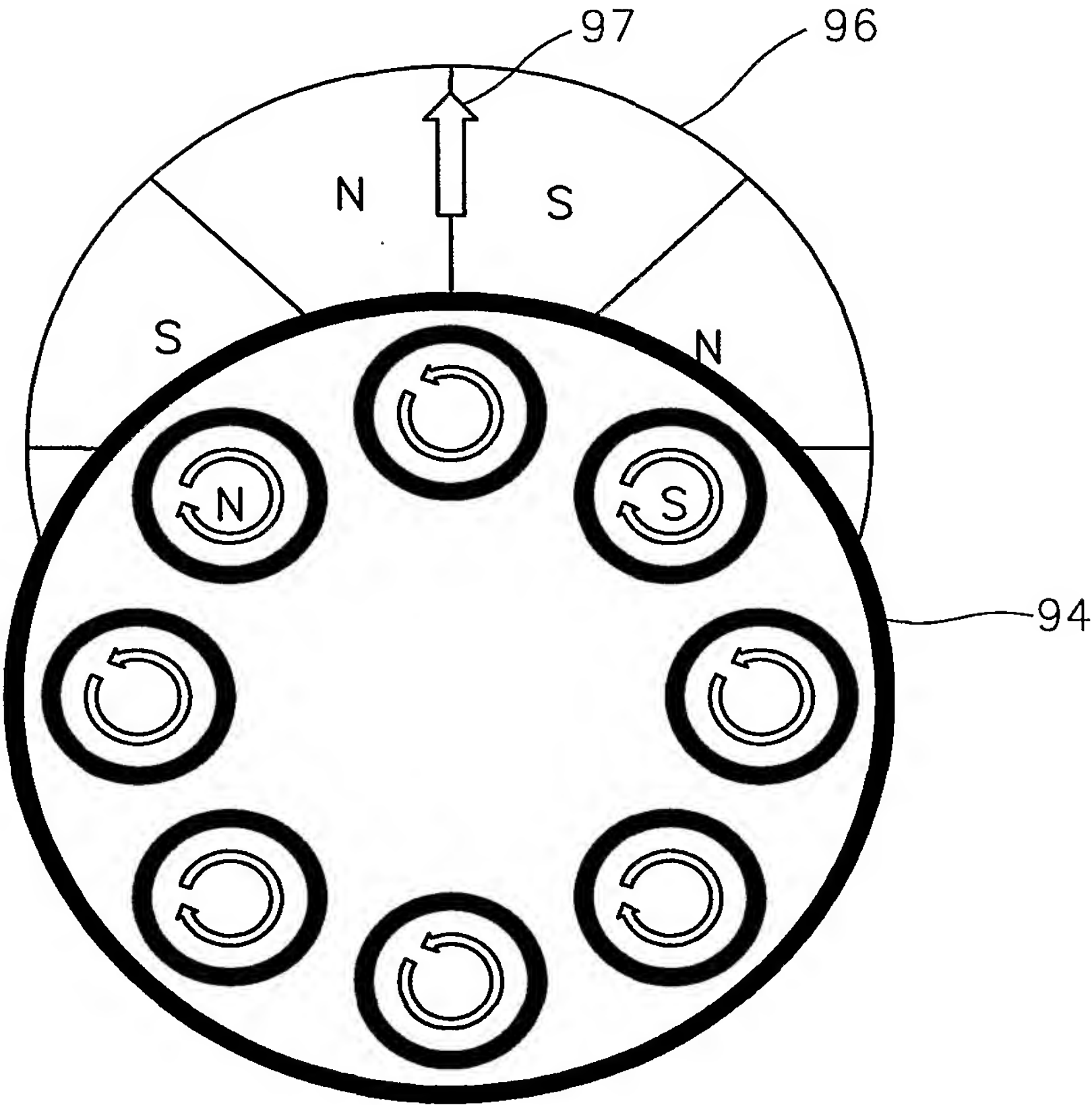
34/39  
**FIG. 36**



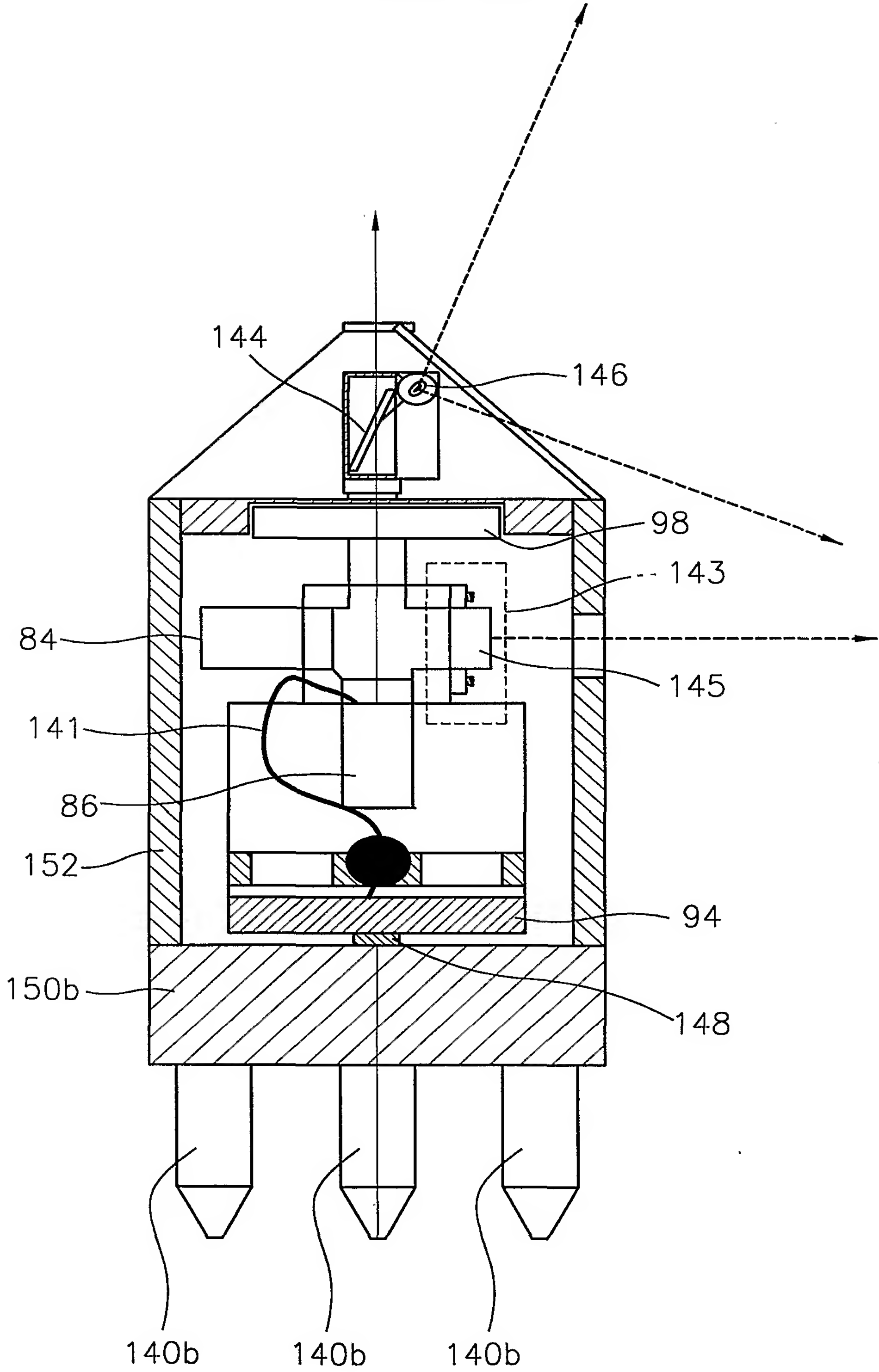
35/39  
**FIG. 37**



**FIG. 38**

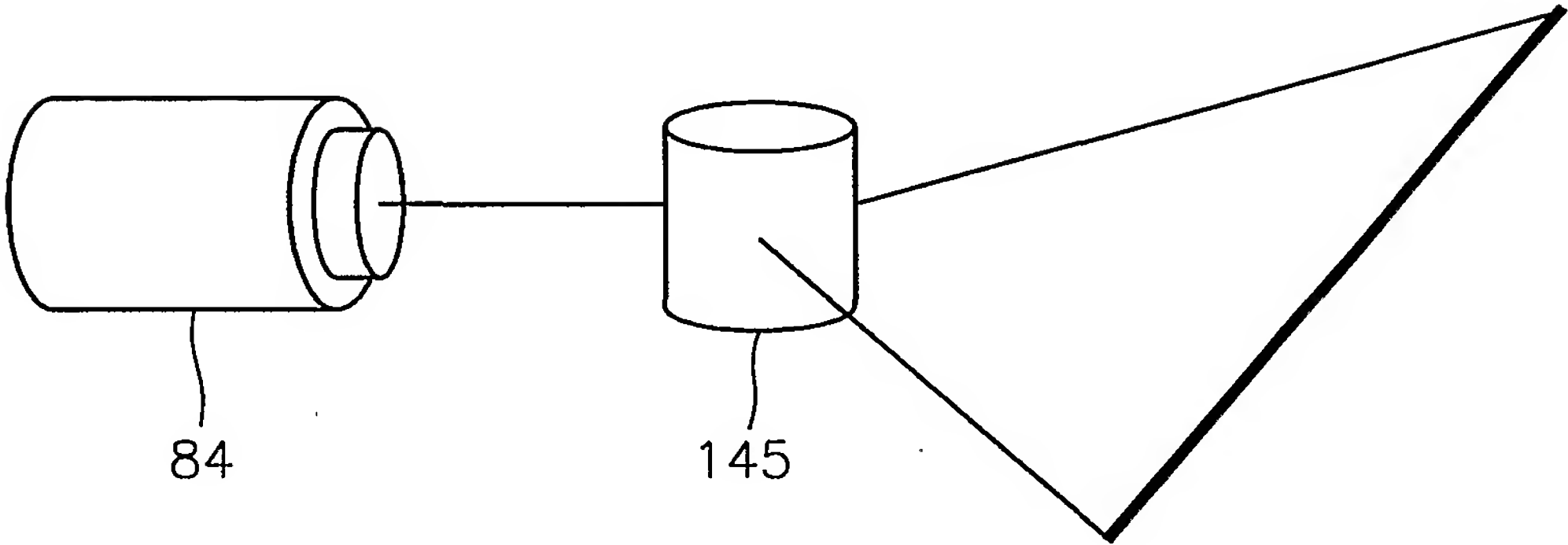


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**FIG. 39**

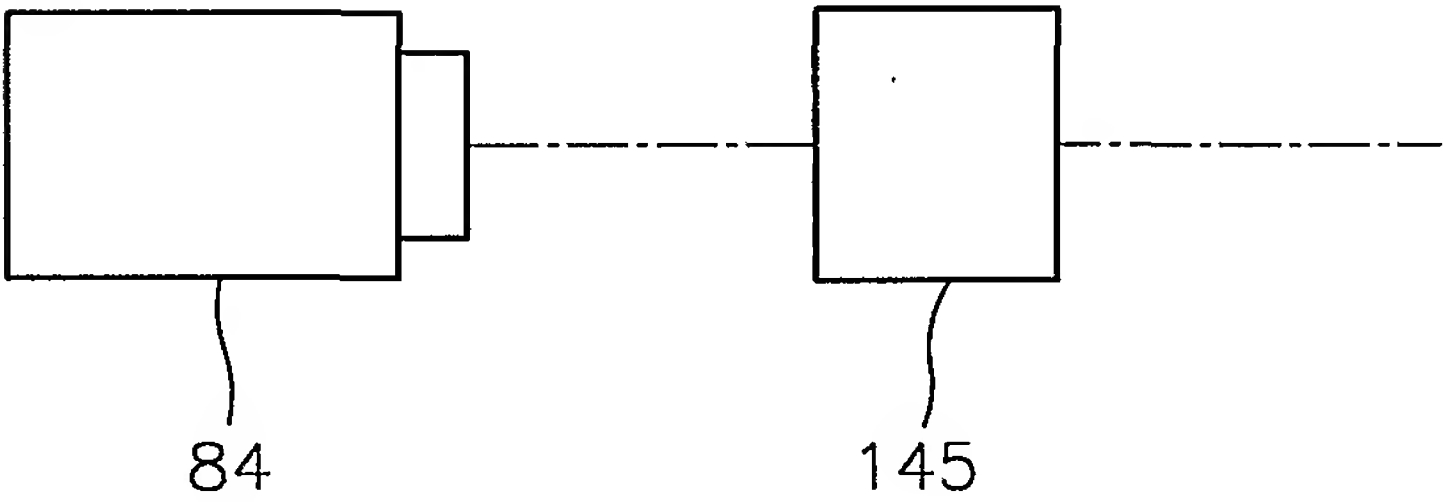




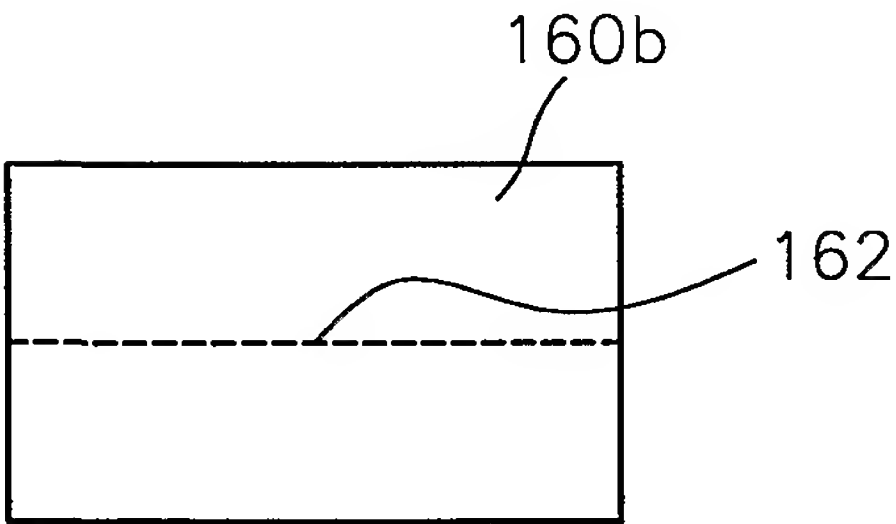
37/39  
**FIG. 40**



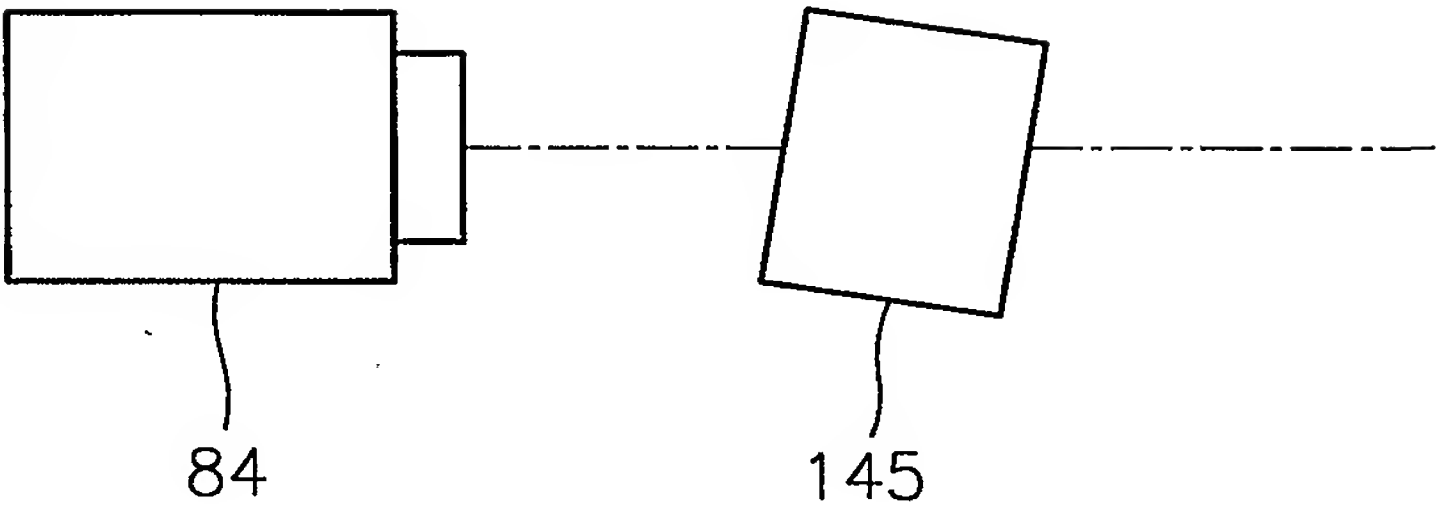
**FIG. 41**



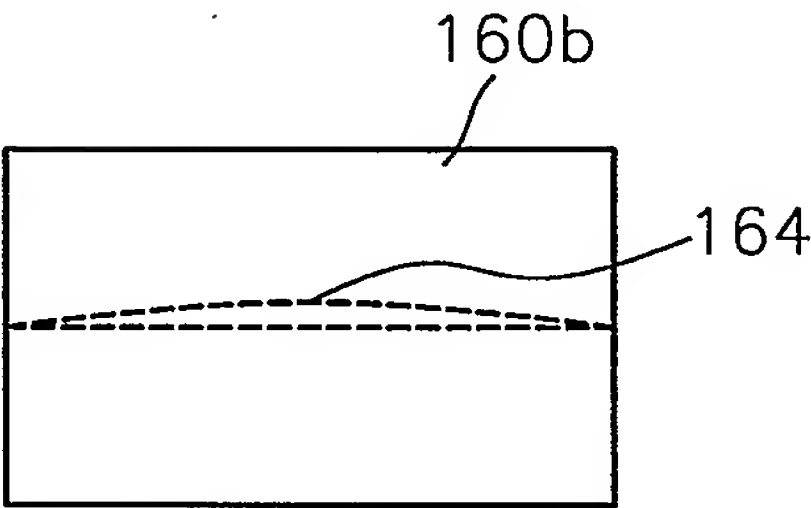
**FIG. 42**



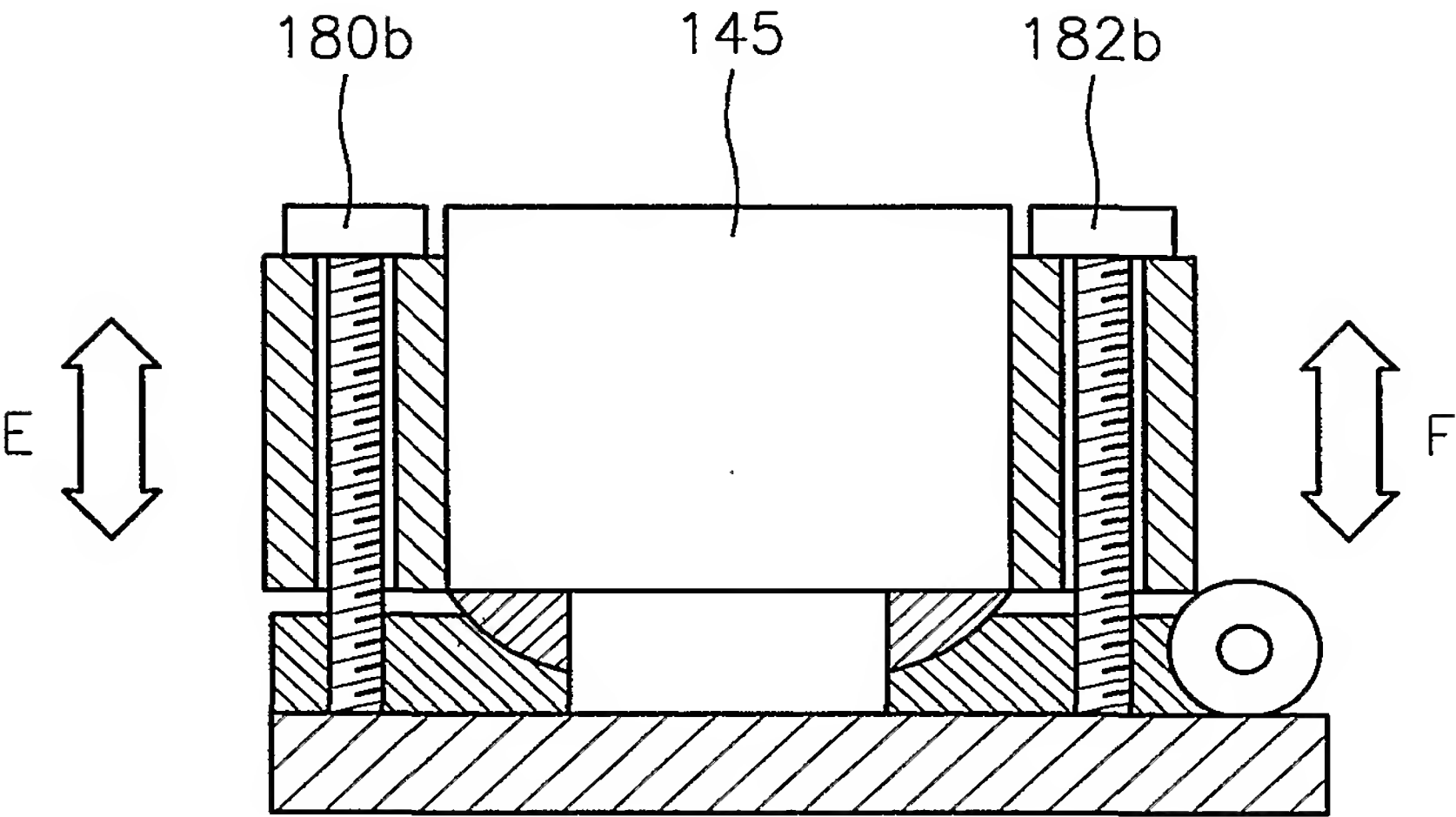
38/39  
**FIG. 43**



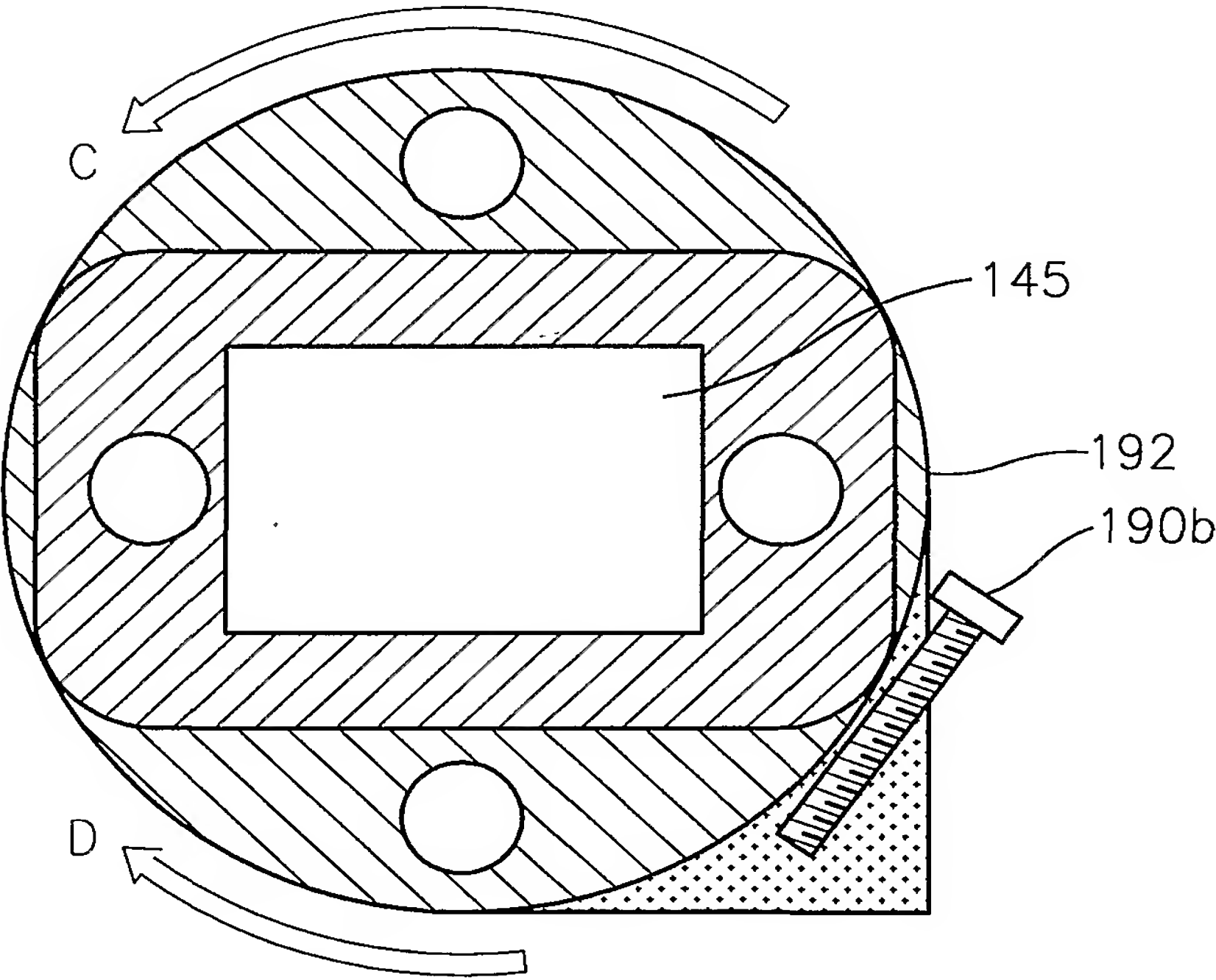
**FIG. 44**



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**FIG. 45**



**FIG. 46**



# INTERNATIONAL SEARCH REPORT

International application No.  
PCT/KR00/01094

## A. CLASSIFICATION OF SUBJECT MATTER

**IPC7 G01C 15/00**

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC7 G01C 15/00, 15/10, 9/06: G12B 9/08

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Korean Patents and applications for inventions since 1975

Japaneses Utility models and application for Utility Models since 1975

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 8-226820A (SUIDO KIKO KAISHA LTD) 03 SEPTEMBER 1996, see the Claims	1-7, 14
Y	JP 10-253356A (TAISEI CORP.) 25 SEPTEMBER 1998, see the Claims	1-7
Y	JP 6-213665A (TERUUCHI HIDEO) 05 APRIL 1994, see the Claims	14
A	JP 8-226820A (SUIDO KIKO KAISHA LTD) 03 SEPTEMBER 1996, see the whole Document	1-24

☐ Further documents are listed in the continuation of Box C.

☐ See patent family annex.

\* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

30 JUNE 2001 (30.06.2001)

Date of mailing of the international search report

30 JUNE 2001 (30.06.2001)

Name and mailing address of the ISA/KR

Korean Intellectual Property Office  
Government Complex-Daejeon, Dunsan-dong, Seo-gu, Daejeon  
Metropolitan City 302-701, Republic of Korea

Facsimile No. 82-42-472-7140

Authorized officer

KONG, In Bok

Telephone No. 82-42-481-5494

